

**Food Habits and Economic Relations of the Turtles
of Michigan with Special Reference
to Fish Management**

KARL F. LAGLER



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for the degree of Doctor of Philosophy in the University of Michigan.

Food Habits and Economic Relations of the Turtles of Michigan with Special Reference to Fish Management¹

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Food Habits and Economic Relations of the Turtles of Michigan with Special Reference to Fish Management¹

Karl F. Lagler

Introduction

This report, based on a combination of field and laboratory studies, is one of a series dealing with predation on fresh-water fishes as related to the practical problems of fish yield (Lagler, 1937). Researches on the physical, chemical, and on the more familiar biological features of fresh-water communities need to be supplemented by studies on the role of predation in their dynamic economy. Although the reduction of populations of predatory and so-called "noxious" animals is a common fish management practice, it often has little scientific basis and is for the most part of unknown effect. It is the purpose of the present study to learn which turtles, if any, retard the production of fish, to experiment with methods of control, to establish "a clean bill of health" for deserving species, and to determine other economic relations of these reptiles.

Acknowledgments.—I acknowledge with sincere gratitude the generous and varied assistance of Carl L. Hubbs, Helen T. Gaige, A. S. Hazzard, and J. Clark Salyer, II.

Josselyn Van Tyne, Thomas Hinshaw, and Milton B. Trautman aided in the identification of bird remains. Ruth Marshall determined the water mites and J. W. Leonard, most of the insects. Calvin Goodrich and Henry van der Schalie are responsible for the specific determinations of the mollusks. Karl E. Goellner identified the amphipods and many of the decapods and G. W. Prescott, the algae. Ralph Peacock and Ann Peacock contributed many turtle specimens. To these individuals and to the many others who helped in innumerable ways, I extend my sincere thanks.

Procedure.—Being primarily concerned with the effect of turtles on fish yield, I have emphasized the study of the more abundant and aquatic species.

¹ Contribution from the Institute for Fisheries Research of the Michigan Department of Conservation and from the Department of Zoology and the Museum of Zoology of the University of Michigan. Substantial financial aid was given this study by the American Wildlife Institute and the Associated Fishing Tackle Manufacturers.

I include also the accumulated data for the less extensively investigated spotted turtle, the more terrestrial wood turtle, and the box turtle.

Studies on the relationships between turtles and fishes and on turtles as an economic resource were made in the field, from April through October in 1937, and from May through September in 1938. During these periods many turtle specimens were collected for food analyses, mostly by means of turtle traps. The stomach and colon contents of these individuals were subsequently analyzed by the most practicable quantitative and qualitative methods similar to those described by Salyer and Lagler (1940). Volumes of food items in stomachs were measured by displacement of water in graduated cylinders; volumes for those in intestines were estimated.

For each turtle species summaries of the quantitative relations of foods eaten and their frequency of occurrence have been made. In addition annotated lists of food items are presented. In these lists details of the numbers, identity, condition, and sizes of food organisms found are given. These data are useful in the interpretation of the volumetric and frequency of occurrence percentages in the tables, since in the lists each food group is broken down into its component items. This analysis also serves to disclose more of the interactions between predator and prey (e.g., differential vulnerability of prey organisms) and between prey species themselves (e.g., buffer effects).

Analysis of the contents of the entire digestive tract was made when possible in preference to sole study of the materials in stomachs, intestines, or droppings. For turtles at least, investigations based on any of these alone are misleading because of: (1) persistence of hard parts of some animals, such as the exoskeletons of crayfish and insects; (2) differential rate of digestion of various materials ingested; and (3) the delayed digestion of cellulose. It is unfortunate that no information is extant regarding rate of digestion, daily food requirements, and periodicity of feeding for turtles. If it were, it would be possible to greatly extend the application of the current findings.

Published information on the species of turtles native to Michigan has been reviewed, but is not repeated in the accounts of each species. Most important references on turtles are readily available; many of these, in addition to those cited, are listed in the bibliography.

The nomenclature followed for turtles is that of Stejneger and Barbour (1939) except for the painted turtles which is after Bishop and Schmidt (1931) and Hartweg (MS). Plant names are from Fassett (1940) and fish names are after Hubbs and Lagler (1941).

Results of Correlated Field and Laboratory Studies

In this section each species of turtle is discussed in systematic sequence. Descriptions and general range are not given since they may be found in the works of Ruthven, Thompson, and Gaige (1928), Conant (1938), and others. Some knowledge of the distribution is important for an understanding of the extent of the area to which the data here presented may pertain; maps by Conant (1938) showing range in the United States are therefore reproduced,

with his permission. Distribution in Michigan is compiled from Ruthven, Thompson, and Gaige (1928), the unpublished data of Helen T. Gaige and Norman E. Hartweg, and from my collection records. Maps of the state are given for each species, to show locations and water types from which specimens were studied for food.

STERNOTHERUS ODORATUS (Latreille)—Musk Turtle

Range and Size.—In Michigan the musk turtle has not been recorded from waters north of Town Line 16 (a line running east and west through the southern part of Saginaw Bay) and is as yet unknown from several of the southern counties (Fig. 1). The musk turtle in this region averages less than five inches in carapace length; the largest males and females examined ranged from 114 to 121 mm. (4.5 to 4.8 inches) in horizontal carapace length.

Habitat and Habits.—An excellent account of the natural history of this preeminently aquatic turtle in the Ann Arbor, Michigan, region has been published by Risley (1933). To this fine study I can add new data on food habits.

The musk turtle has been found in the quiet waters of lakes, ponds, and slow-moving streams throughout its range. In Michigan I have collected it most commonly in those portions of lakes, or lagoon-like sections of rivers, where aquatic vegetation grows abundantly but not so densely as to impede greatly the movements of turtles on the bottom. Particularly favorable environments were the reedy, firm-bottomed areas of such lakes as Whitmore (Washtenaw County), Sherman (Kalamazoo County) and Wolf (Van Buren County). This turtle is doubtless more abundant than commonly assumed. It is unobtrusive, not only because of the luxuriant growth of the alga *Basilcladia* on the backs of many individuals, but also because of its predominantly nocturnal and secretive habits. Although individuals were seen foraging at all hours of the day, they appeared to be more active at night. Specimens collected by hand at night were usually moving over open bottom. Those taken in the daytime were most often hidden, at least partly, under some sheltering object.

Food and Feeding Habits.—The feeding activities of this turtle appear to be confined to its aquatic environment. Occasional feeding on land is reported by other investigators (Newman, 1906).

Newman (*loc. cit.*), Evermann and Clark (1920), and Risley (1933) have reported the scavenging habits of this turtle. On the basis of the lack of response of musk turtles, or of any other Michigan turtle, to putrefying bait in traps, it seems that such scavenging may have been overestimated. Musk turtles have been observed by me to feed readily on freshly dead material but to refuse animal flesh in advanced stages of decay. The word "scavenger," then, as used in the present paper, should be taken to mean feeding on dead, but not putrefied material.

My studies of the food of the musk turtle are based on 113 specimens which contained food either in the stomach or colon, or in both of these organs. These turtles were collected mostly during late summer months of

River drainage, has a surface area of 677 acres and maximum depth in excess of fifty feet. The bottom is varied; sand, gravel, mud, and some marl appear extensively in the shoal areas. Several species of pondweed (*Potamogeton*), and hornwort (*Ceratophyllum demersum*), dominate the aquatic flora. Game and pan fishes present include largemouth bass (*Huro salmoides*), northern smallmouth bass (*Micropterus d. dolomieu*), yellow perch (*Perca flavescens*), common bluegill (*Lepomis m. macrochirus*), pumpkinseed (*Lepomis gibbosus*), and northern pike (*Esox lucius*). Associated with these are several species of minnows and other forage fishes, northern longnose gar (*Lepisosteus osseus oxyurus*), and bowfin (*Amia calva*).

The thirty-four musk turtles studied for food from this lake averaged 95 mm. (3.7 inches) and ranged from 70 to 115 mm. in length. They were collected in September and October of 1937. The stomachs of nineteen of these turtles contained food with a total volume of 2.7 cc. Thirty-two colons contained 28.0 cc. of food. These organs, in the remaining individuals of this series, and in several additional individuals collected from this lake in these months, were devoid of food. The snapping turtle, mid-western painted turtle and map turtle were also studied in Whitmore Lake.

In Whitmore Lake, in autumn, aquatic insects and their nymphs and larvae, snails, and carrion appear to be the most important food of this turtle. Fish carrion is more prominent in volume relationships in the stomachs than in the colons. Green plants, however, appear more prominently in colons than in the stomachs. Insects and snails comprise approximately the same proportion of the contents of both organs.

The aquatic insects most often taken were dragonfly nymphs and lepto-cerid caddis larvae, frequently *Leptocella albida*. Terrestrial insects were represented by eleven ants in one stomach, and by a larval lepidopteran in another.

The strong jaws with their broad occlusal surfaces appear to be correlated with mollusk- and seed-eating habits. For the most part, the mollusks and seeds of aquatic plants in the stomachs of this turtle are crushed beyond recognition.

All fish remains encountered were carrion. Earlier in the season, in July, when many more game fishes are killed, the species is even more a scavenger than in late summer. M. B. Trautman tells me that while fishing on this lake, he has observed musk turtles feeding on fish injured by anglers and also upon dead or dying bait "minnows" dumped from the fisherman's live-bucket.

Sherman Lake.—This lake is approximately one hundred acres in surface area (Henshaw, 1931), and has fairly extensive shoal areas with a bottom of sand, gravel, muck, and marl. The shores are hilly and partly open with meadows and partly wooded with some resort development, and much of the shore line is inaccessible by road. The dominant aquatic vegetation includes several large beds of *Nuphar advena* in the sheltered coves and species of *Potamogeton* in the more open waters. *Anacharis canadensis*, *Ceratophyllum demersum*, *Myriophyllum*, and *Chara* are common. Some bulrushes (*Scirpus*) and cattails (*Typha*) occur in a few restricted localities. Game and pan fishes present are largemouth bass, northern smallmouth bass, northern rock bass

(*Ambloplites r. rupestris*), several species of sunfishes (*Lepomis*), yellow perch and bullheads (*Ameiurus*). Minnows, darters, and a few eels (*Anguilla bostoniensis*) also occur.

The abundant and varied aquatic fauna and flora, the extensive shoal area with soft bottom, the limited resort development, the sandy banks and open meadows on much of the shore, and the absence of a marginal road favor the turtle population of this lake.

Food habits data for the musk turtle from Sherman Lake are based on 11.7 cc. of food contained in the stomachs of twenty-eight specimens. In length these turtles average 95 mm. (3.7 inches) and range from 60 to 110 mm. Excepting two individuals collected on August 20, 1937, all were taken from September 16-18, 1938. For comparison it should be noted that digestive tract contents of snapping, Blanding's, and mid-western painted turtles from this lake were also analyzed.

Insects, snails, and carrion appear as the most important foods of this turtle in Sherman Lake as in Whitmore Lake. The most common insects taken were leptocerid caddis larvae and the most frequently encountered snails were *Helisoma* and *Amnicola*. Seeds of aquatic plants appeared rather abundantly. Carrion was found to be entirely the remains of fish. The single pan fish was a yellow perch $1\frac{3}{4}$ inches long, apparently alive when taken.

Miscellaneous lakes.—Thirty-five specimens collected throughout the two summers of field work in several lakes give a picture which substantiates those for Whitmore and Sherman Lakes. The average length of thirty-two of these turtles on which measurements were obtained is 98 mm. (3.9 inches); the range is 79 to 122 mm. The stomachs of twenty-one of these individuals contained 2.3 cc. of food for study and the colons of twenty-seven, 18.7 cc.

Insects, mollusks, and vegetable matter appear as the principal foods. The insects most frequently encountered were dragonfly nymphs and the mollusks were predominantly snails of the genera *Helisoma* and *Physa*. Crayfishes assume greater importance. As before, the vegetable matter encountered was very largely composed of the cracked or crushed seeds of aquatic plants.

Rivers.—The series of nine specimens available from sluggish river habitats gives results that strikingly resemble those for lakes. The average length for eight of these specimens was 99 mm. (3.9 inches); the range, 91 to 112 mm. Five contained a total of 1.0 cc. of food in their stomachs and seven had 4.7 cc. of such material in their colons.

Crayfishes assume somewhat greater significance in the food of musk turtles in this type of water. The insects eaten are again predominantly dragonfly nymphs, and the hard-coated seeds of *Nuphar advena* form the major part of the vegetable matter ingested.

Fish cultural establishments.—The series of eight specimens available for an appraisal of the status of the musk turtle at fish cultural stations is small. Excepting one specimen taken from a bluegill rearing pond at the Drayton Plains Hatchery on June 24, 1932, the turtles came from an ornamental and

forage fish rearing pond of the Sunset Water Gardens, near Milford, on September 26, 1937. The length of seven of these specimens was 89 to 97 mm., averaging 93 mm. (3.7 inches). Food was found with a total volume of 3.2 cc. in six stomachs and with a total volume of 2.0 cc. in four colons.

An estimated thousand and more bluegill larvae were taken by J. C. Salyer, II, from the stomach of an individual collected from a bluegill nest at the Drayton Plains state fish cultural station.

At the Sunset Water Gardens' pond, the food of the turtles hardly differs in any essential respects from that found on wild waters. The small pond from which the turtles were obtained contained many thousand young bluntnose minnows (*Hyborhynchus notatus*), topminnows (*Fundulus diaphanus*) and goldfish (*Carassius auratus*). Whether or not the eggs and larvae of these fishes are subject to musk turtle predation is not known, although presumably they may be eaten in some numbers during the bottom foraging and rooting activities of this small turtle. If one may base any conclusions on data so limited, it would seem that healthy adult and juvenile fishes are in general free from predation by musk turtles, even though they are very crowded and the turtles are possibly more numerous per unit area than in any natural water. No fish were found in the food of these specimens.

ANNOTATED LIST OF ITEMS IN THE FOOD OF 113 MUSK TURTLES

Game and pan fishes.—Such fishes were represented by one yellow perch $1\frac{3}{4}$ inches long, more than a thousand bluegill larvae (in a single turtle) and remains of two unidentified centrarchids. The bluegill larvae were in a specimen from a fish hatchery; the other items, in specimens from natural waters.

Unidentified fishes.—Remains of three unrecognizable fishes were found.

Carrion.—Remains of the bowfin, bluegill, pumpkinseed, and several centrarchids and unidentified fishes were recognized as carrion.

Leeches.—Two partially digested leeches were present.

Crayfishes.—Of the remains of 25 crayfishes (*Cambarus*), 2 were identified as *C. virilis*.

Insects.—In addition to fragmentary remains of many insects the following were determined: 6 mayfly nymphs including 1 *Caenis* and 2 *Hexagenia*; 1 grasshopper (*Melanoplus m. mexicanus*); *Anax junius*, *Leucorrhinia*, and *Celithemis* once each among the parts of 64 dragonfly nymphs; 6 damselfly nymphs, of which 1 was *Enallagma*; 3 Hemiptera, (*Ranatra*, *Pelocoris*, and a belostomatid); 11 beetles include 1 carabid, 3 dysticids, 5 hydrophilids, 1 coccinellid, and 1 rhynchophoran; 298 caddisfly larvae of which 29 were unidentifiable and the remainder made up of 36 *Leptocella albida*, 232 leptoцерids, and 1 limnephilid; 2 moth larvae of which 1 was a pyralid; 5 Diptera of which 2 were pupae and the remainder larvae of the groups Chironomidae, Stratiomyidae, and Brachycera; 13 Hymenoptera, 1 unidentified specimen and 11 winged ants (Formicidae), and 1 bee (*Apis mellifera*).

Snails and clams.—Of the mollusks found, the remains were largely bits

of almost completely decalcified shell. Only one could not be identified as to whether it was a snail or a bivalve. Snails recognized were 39 *Helisoma* (13 *H. triolvis*, and 12 *H. antrosom*), 17 *Physa sayii*, 7 *Physa* sp., and 36 *Amnicola*. More than 20 additional snails were represented by soft parts only. Of several bivalves, 2 were *Pisidium*.

Plants.—Of the cryptogams, filamentous algae were the most common but miscellaneous colonial algae, *Chara*, and some mosses were also present. Phanerogams were often represented by fragments of leaves, stems, and seeds which lacked diagnostic properties and were therefore classed as "vegetable debris." Flowering plants occurred mostly as vegetative portions of the aquatics, *Potamogeton*, *Najas*, *Anacharis canadensis*, *Spirodela polyrrhiza*, *Ceratophyllum demersum*, *Ranunculus*, and *Utricularia*. Seeds of *Nuphar advena* numbered 69, of *Nymphaea odorata*, 29, and of *Bidens*, 4. One seed of a dogwood (*Cornus Amomum*) was also found.

SUMMARY AND CONCLUSIONS

That the musk turtle is an omnivore is conclusively demonstrated (Table 1 and Fig. 6). Stray insects, such as grasshopper, terrestrial beetles, the lepidopteran larva, and the bee and ants, are doubtless taken after they fall into the water, and thus do not affect the conclusion that this turtle is essentially aquatic in its feeding habits.

Although a few fishes are eaten, this so-called damage may be more than counterbalanced by feeding on other "enemies" of fish. Such insects as the predacious belostomatids and diving beetles may be placed in this category. Seeds of the "beggar-tick" (*Bidens*) appear to be injurious to fishes (Leonard, 1938).

Excepting possible harm by predation at hatcheries and on eggs and larvae of desirable species of fishes, it would seem that the principal adverse effects of the musk turtle on fish populations may be in the numbers of fish-food organisms that it eats. Benefits may accrue from its scavenging habits, its consumption of mosquito larvae, its destruction of mollusks that figure in the life cycles

TABLE 1.—The Food of the Musk Turtle in Natural Waters in Michigan.

Food Item	Stomachs		Colons	
	Composition by Volume	Frequency of Occurrence	Composition by Volume	Frequency of Occurrence
	(%)	(%)	(%)	(%)
Game and pan fishes	6.2	0.8	1.6	1.1
Unidentified fishes			TRACES	1.6
Carrion	40.1	5.8	4.9	3.2
Crayfishes	6.2	3.3	10.6	9.7
Insects	16.9	34.2	23.6	26.9
Snails and clams	23.2	28.3	34.7	24.7
Cryptogams and Phanerogams	3.4	15.0	7.7	14.0
Vegetable debris	4.0	12.5	16.7	18.8

of parasites of fish and other animals, and possibly from its dissemination of undigested, viable seeds of aquatic plants.

CHELYDRA SERPENTINA (Linnaeus)—Snapping Turtle, Common Snapper

Range and Size.—In Michigan the snapping turtle probably occurs in every county (Fig. 2) but is most common to the south. It attains the greatest size of any of the turtles of the state. The average carapace length of 204 of the individuals trapped is 238 mm. (9.4 inches) ranging from 51 to 373 mm. The largest specimen weighed thirty pounds. Snapping turtles up to seventy

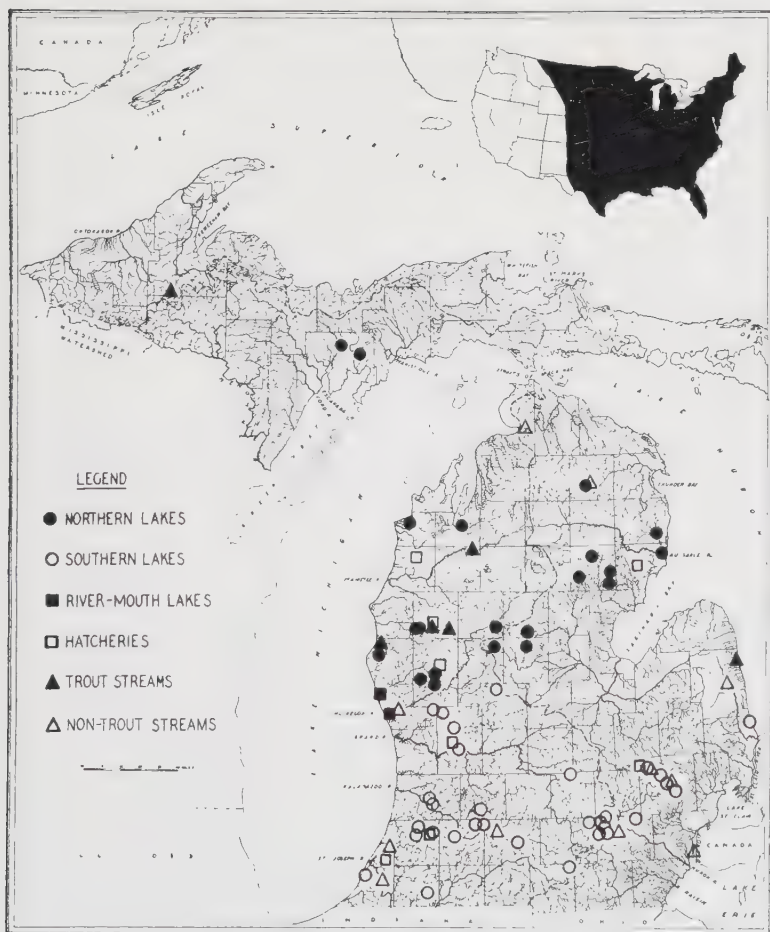


Fig. 2. Types and locations of waters from which snapping turtles were studied and general range of the species in the United States.

pounds in weight are reported by turtle trappers. Abbott (1884) saw a specimen in New Jersey that weighed sixty pounds and reports having been told of heavier ones.

Habitat and Habits.—Published observations on the habitat of the snapper show that even very small bodies of water are inhabited by this species. In New York, near Newburgh, I took a large adult from an isolated residual pool in a small stream. W. S. Blatchley (1891) found five individuals in a similar, though smaller, "mud-hole" in Indiana. Specimens in Michigan have been collected in streams, rivers, pools, ponds, and lakes of great variety and even at a distance from water. Those waters which yielded greatest returns per unit of effort expended in obtaining snappers from them were: soft-bottomed lakes and ponds in the southern half of the Lower Peninsula; lagoon-like sections of larger rivers such as the St. Joseph near Three Rivers and the Muskegon about seven miles east of the city of Muskegon; and river-mouth lakes such as White and Muskegon Lakes.

Faced with a potential enemy on land, a turtle of this species does not ordinarily retreat within its shell or move in the opposite direction as do other Michigan turtles, but at once faces-off and may even move to the attack. In the water it is more gentle; I once saw a professional turtle hunter, with bare feet and legs, enter a small live-pen crowded with sizeable snappers and worm his feet among the animals to obtain a footing on the bottom. He stood unharmed in this pen for twenty minutes while handling thirty-seven snappers one by one for examination. This species in water tends to flee the observer or collector.

The snapper is well defended by its strong jaws, which close with remarkable speed, and protected by its heavy carapace. The common name "moss-back" refers to the luxuriant, obliterative mat of firmly attached algae, predominantly *Basicladia*, that flourishes on the backs and on the upper parts of the tails of many individuals. The turtles are thus concealed from their enemies and their chance of capturing prey is increased.

I have collected specimens during the months of April through September, inclusive; but there are occasional records of capture for other months. Individuals are not infrequently seen moving about under the ice. Evermann and Clark (1920) recorded having seen a large specimen just under the ice in Lost Lake, Indiana, on December 18, 1900; it appeared to be too much benumbed to move away even when a hole was chopped through the ice to effect its capture. Emil Krasny, of Whitmore Lake, Washtenaw County, reported obtaining a twenty-pound individual in a like manner from Whitmore Lake early in the winter of 1937-38 just after the first freeze, while the ice was yet clear. On January 26, 1938, the Michigan Department of Conservation Official News Bulletin reported a specimen having been taken under the ice in a muskrat trap in Evans Lake, Lenawee County. Kilham (1929) found a small torpid specimen in the mud of an estuary in the Charles River at Cambridge, Massachusetts, during a February thaw. In spite of the occasional discovery of snapping turtles active during the winter months, it appears that this turtle generally hibernates, from early fall (October) to early spring (March).

Hibernating snapping turtles are usually to be found in the bottom of waterways, sometimes singly and at other times in large aggregations in selected spots such as muskrat burrows, the mouths of tributary streams, in spring inlets, and under logs and banks. Some turtle hunters make large hauls from hibernating concentrations. Earl Bixby, of Berrien Springs, took five hundred pounds of snappers in the early spring of 1937 from a small channel between two of the Grand Marais Lakes just west of Stevensville, Berrien County. These turtles were buried under from one to two feet of the soft bottom material in this channel and were located and hauled out by means of an iron rod with a hook at one end. Hibernation in similar sites has been reported by Abbott (1884), Newman (1906), Clark and Southall (1920), Cahn (1937), Conant (1938), and others.

During warm seasons, the snapping turtle is found in shallow water, beside logs, stumps, or hummocks, at times lying partly buried in the mud. The depth of water selected is usually not greater than the length of the head and neck extended, for turtles lying in this manner run the head to the surface at intervals in order to breathe. It is not given to basking in the sun on logs. Presumably by retaining an extra amount of air in the lungs snappers are able to float, motionless, at the surface of the water with the eyes and nostrils just exposed. In this position they are often shot at by irresponsible persons, an important consideration if conservation of the species is deemed wise.

Food and Feeding Habits.—Snapping turtles do not ordinarily swallow food out of water. In the reptile pit at the Museums at Ann Arbor, ground beef repeatedly placed beside the pool of water was taken into the pool by snappers before it was swallowed. I have suspended a freshly killed carp (*Cyprinus carpio*) out of water in a turtle trap and have watched captive snappers come up and secure a mouthful at a time and retire under water to swallow the morsel. One snapper repeated such feeding seven times in twenty minutes, until the supply had been exhausted. Since terrestrial organisms, plant and animal, are sometimes found in the food of *Chelydra* it is probable that feeding out of water is possible.

In trapping snappers, fresh bait gave the best catches. This was contrary to reports, and a series of simple experiments was drawn up to learn how freshness determined palatability for this species. These experiments, executed by R. M. Stow under the supervision of M. D. Pirnie, were conducted in an aquarium at the W. K. Kellogg Bird Sanctuary in mid-summer. Three adult specimens, 8.1, 10.2, and 10.9 inches long respectively, were placed in a tank about three by four feet with water about two feet deep, and kept without food for six days. A small amount of chicken entrails, kept at room temperature, was offered to the turtles each day until the day on which all three refused to eat. All three turtles ate the allotment of entrails on the first three days of the experiment. On the fourth day, the small one refused to take the food, but the medium-sized turtle ate it. The largest turtle refused the morsel offered it on the fifth day, as did the smallest. On this day, the medium-sized turtle was offered two bits of food; one of which floated while the other sank to the

bottom. That which sank was taken first; the floating piece later. On the sixth day all three turtles refused to take the offerings of entrails, which by this time were exceedingly foul.

Similar tests were repeated using dead fish kept at room temperature as food, and employing the medium-sized individual as the subject. This turtle, after being without food for five days, took the fish offered for the first five days of the experiment and then refused to feed on the sixth and seventh days. By the sixth day the fish was in advanced stages of decay.

On another occasion a decaying piece of a fish that had been dead for four days was offered the 10.2-inch snapper. Immediately after the turtle had begun to eat, a piece of freshly killed fish was introduced into the opposite side of the tank. In less than a minute the turtle left the decomposing fish and went to the fresh fish and ate it. He then returned to the putrifying fish but ate no more of it; he poked it around for some time with his snout and then left it. These experiments tend to refute the common belief that the more foul the food, the more tempting it is to the snapper.

Snapping turtles feed in three distinctive ways: (1) small prey is sucked with a sudden gulp (Conant, 1938: 127); (2) large animals are seized by the jaws and held till dead, or nearly dead, and are then torn into pieces by combined action of the jaws and front feet; and (3) vegetable matter and soft-bodied animals are bitten into sections and swallowed. It is of interest that in attacking a plant stem or leaf or other resting object, the snapper uses the same swift movement of the head and jaws as when a moving animal is seized. These turtles are bottom, mid-water, and surface feeders. Fish eggs and crayfishes are taken from the bottom. Fishes of several kinds and some plants are taken from mid-water. Algae, pond lily leaves, snails, and some insects are taken from the surface.

During bottom feeding activities, snappers often root about the large rhizomes of *Nuphar advena* and frequently break off sizeable sections, which come to the surface and are taken by professional trappers as a sign that snappers are present. Snapping turtles also "roll" the vegetation during foraging activities. This "rolling" is particularly evident in beds of *Chara* where sizeable areas of the bottom may be cleared and the vegetation moved off to one side, usually toward the shore.

Bird remains have been found in snappers by Hay (1892) and by Sontag (1924). Newman (1906) saw young ducks eaten and Hurter (1911) gives a similar record. Bralliar (1922) observed the capture of a young trumpeter swan and Buckle (1925), a hawk. Abbott (1884) saw a muskrat dragged down under water. Crayfish have been found in snappers by Hay (1892) and by Paul L. Errington (unpublished notes), and snails are reported by Evermann and Clark (1920). Hatt (1932) came upon a specimen feeding on a dead green heron and Conant (unpublished notes), on one eating a dead snake. Conant also writes me that he has seen a snapper eat a freshly caught fish. Errington has written that specimens from Iowa examined by him also contained terrestrial and aquatic beetles, frogs, and vegetable matter.

The only previous detailed study of the food of the snapping turtle is that of Surface (1908) based on nineteen specimens containing food. The stomachs of five of these turtles contained plants: algae, apple seeds, leaves of skunk cabbage (*Symplocarpus foetida*), grass, and undetermined seeds and leaves. All nineteen had eaten animal matter. Snails and slugs were present in seven. Insects, found in nine, included bugs of the families Corixidae and Pentatomidae, fly larvae including Stratiomyidae, and beetles including members of the families Hydrophilidae, Dytiscidae, and Gyrinidae. Vertebrate remains, recognized in seven individuals, were fishes (suckers of the family Catostomidae among them), and frogs, snakes, birds, and mammals (mice and remains of a rabbit).

That the snapping turtle is not wholly carnivorous but rather omnivorous was early suggested by Hay (1887) and substantiated by Surface (1908). Babcock (1916) also found plant material (marsh grass, *Distichlis spicata*) in a specimen. The omnivorous habits of the snapping turtle are also shown in an unpublished study made at Portage Lake, Washtenaw and Livingston counties, by Lyle S. Hubbard under the direction of Carl L. Hubbs in 1920. A large proportion of the contents of stomachs examined by Hubbard was composed of segments of water lily stems, plant food predominating over the animal matter.

In captivity, snapping turtles will eat a great variety of animal and vegetable substances. In my laboratory they have been fed on ground beef heart, dead flies and moths, crayfishes, earthworms, and fishes. In the reptile pit at the Museums, lettuce and ground beef are fed to snapping turtles.

Observations on the food of young individuals also indicate omnivorousness. Surface (1908) found young turtles feeding on insects, especially beetles, and also on small fishes, crayfish, and snails. Newman (1906) reported that they eat larvae of insects that are found by burrowing in the mud. Linsdale (1927) found cricket frog remains in a small specimen. The smallest individual (65 mm. in carapace length) examined by me was taken from the Clinton River at Drayton Plains on July 8, 1937, at 3:00 P.M. The stomach contained a small northern blacknose shiner (*Notropis h. heterolepis*), three beetle larvae, a leech, and some filamentous algae, with a trace of a crayfish and some vegetable detritus in the colon.

Snappers taken some distance from water give little or no evidence of having fed on terrestrial plants or animals. Two in my collections contained food from the aquatic habitat as follows: (1) remains of a large hydrophilid beetle and a trace of watermeal (*Wolffia*) in the stomach, with seeds of beggar tick (*Bidens*), a small amount of *Wolffia*, remains of a snail (*Lymnaea*), a beetle, and a lepidopterous larva in the colon; (2) remains of three snails (*Physa*) and a trace of filamentous algae. Conant has written me that a small specimen found dead on the road contained the remains of terrestrial Orthoptera.

The food studies of the snapping turtle here reported are based on 323 specimens with food either in the stomach, colon, or both. These turtles were

collected during the months of May through September in 1937 and in 1938 from seventy-two lakes, eleven non-trout streams, six trout streams, and eight fish cultural stations (Fig. 2). In the following report the findings for specimens from each of Wintergreen, Sherman, and East Twin Lakes are discussed separately. Additional series treated individually are those from river-mouth lakes, non-trout streams, trout streams, and fish cultural establishments. This facilitates comparison of the food habits of the snapper in different ecological situations.

Wintergreen Lake.—This body of water at the W. K. Kellogg Bird Sanctuary of Michigan State College is relatively shallow and approximately twenty acres in surface area. The bottom is chiefly marl, with smaller areas of sand and muck. Around one end there are extensive beds of *Nuphar advena* which, with narrow-leaved potamogetons, dominates the aquatic flora.

Both game and forage fish are numerous in the lake. The most abundant sport fish is the common bluegill. Yellow perch, largemouth bass, pumpkinseed, bluegill $\times$ pumpkinseed hybrids, yellow bullhead (*Ameiurus n. natalis*) and brown bullhead (*Ameiurus n. nebulosus*) are also present in some numbers. Forage fishes include four species of minnows, chubsuckers (*Erimyzon*) and the Iowa darter (*Poecilichthys exilis*). The bowfin also occurs.

The twenty-one snapping turtles from Wintergreen Lake afford information on the vulnerability of waterfowl to snapping turtle predation. This is the only lake from which snappers were taken when broods of ducklings, goslings, and cygnets were known to have been present. According to Pirnie (1935), approximately twenty pairs of mallards nest about the lake and swale each year; some Canada geese and mute swans also nest here; adult waterfowl of several species are always present. Inasmuch as snapping turtles have been trapped or shot on this lake since 1927, a surprisingly high number was taken during the summers of 1936 through 1938. In mid-July, 1936, nine individuals averaging about ten inches in length were trapped in two nights. From June 26 through September 4, 1937, the catch for 496 trap-nights was eighteen specimens. From July 5 through August 13, 1938, the take on 153 trap-nights was eight snappers averaging about nine inches in length. Although trapping operations reduce the snapping turtle population in the lake, it seems impossible to eliminate the species entirely.

The food studies of snapping turtles from Wintergreen Lake are based on twenty-one specimens containing food (Table 2). Game fishes eaten were mostly centrarchids. Remains in the colons could not be positively identified as carrion or otherwise. Bluegills and a largemouth bass were present; other sport species taken were yellow perch and yellow bullhead. In all, the turtles studied had accounted for less than one game fish per individual. Even with the assumption that all the game and pan fishes were alive when taken (which is doubtless not true), such a toll could hardly be a menace to the large fish population of this lake. It is possible that removal of some of these fishes from this body of water by turtles or otherwise would benefit the remaining individuals, for the fishing pressure by anglers is light.

TABLE 2.—The Food of the Snapping Turtle in Wintergreen Lake.

Based on thirteen stomachs containing 287.5 cc. of food and on seventeen colons containing 604.5 cc. of food.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game and pan fishes	10.3	46.2	0.4	52.9
Unidentified fishes	TRACE	7.7	0.2	29.4
Waterfowl	27.5	15.4	1.0	5.9
Unidentified birds	0.7	15.4	3.4	29.4
Muskrat	---	---	5.6	5.9
Carrion	5.3	7.7	0.3	11.8
Crustaceans	0.4	30.8	0.1	23.5
Water mites	TRACES	23.1	TRACES	47.1
Insects	0.6	46.2	1.1	88.2
Molluscs	1.7	30.8	0.5	47.1
Cryptogams	49.3	62.5	70.3	88.2
Phanerogams	0.3	38.5	1.8	70.6
Vegetable debris	3.9	38.5	15.4	64.7

Four young mallards were present in three turtles, but it could not be ascertained whether any of the birds were alive and healthy when taken. Director Pirnie, of the Sanctuary, has told me that in his seven summers on the grounds he has never seen, nor have any of his men seen, a bird actually being taken by a snapper. Ducklings have, however, disappeared for undiscovered reasons. In spite of the high concentration and availability of avian prey, it appears that the snapping turtles on this lake turn largely to the still more available aquatic vegetation for food. The turtles certainly cannot be blamed for the entire amount of loss of young waterfowl. There is evidence that largemouth bass, other predacious fishes, and bullfrogs take ducklings.

Feathers alone constituted the unidentified bird remains in one stomach and in two colons. These feathers may have been taken from the water's surface or from the bottom of the lake, or they may represent a bird that escaped from the turtle's attack. No bones or flesh were present with these feathers. Remains of other unidentified birds were found in four additional turtles. The remains of a starling in one individual were classed as carrion since several had been shot near the lake on the day previous to the capture of the turtle.

In Wintergreen Lake, as in many other lakes, the food most available to turtles is aquatic vegetation and this material is by far the most important by bulk and by frequency of occurrence in both stomachs and colons of the individuals studied. Filamentous algae, almost always present in quantities either on the surface or on the bottom of this lake, constituted the major portion of the vegetable matter taken. Many miscellaneous invertebrates, which make up but a small proportion of the total volume but which are always associated with these plants and so have a high frequency of occurrence, were perhaps secondarily ingested with the algae.

Sherman Lake.—This lake is briefly described above (p. 261).

Nineteen common snappers containing food were studied from this body of water. Seventeen of these were collected on August 19-21, 1937, and two on September 16-17, 1938. The average size of eighteen of these specimens was 274 mm. (10.8 inches), ranging from 208 to 305 mm.

Game and pan fishes taken by snappers from Sherman Lake, as for the other lakes studied, were predominantly centrarchids; bullheads and yellow perch were also represented. Fishes in the stomachs were clearly alive when taken; the scanty remains found in the colons could have been carrion. At the most, however, the turtles averaged less than one and one-fourth such fishes per individual, during the time of feeding represented by the stomach and colon contents.

Aquatic vegetation is the predominant food in stomachs and colons and occurs in all colons that contained food remains (18) and in all but one stomach that contained food (14). Filamentous algae form the most important single item in both organs, with *Nymphaea odorata* next. In addition to the quantities of leaves and petioles of *Nymphaea* present in four stomachs and five colons, one of these stomachs and the colon of the same individual contained 11,065 seeds (65 cc.) of this plant. The seeds were apparently mature and very few of the coats were ruptured. As in the case with the musk turtle, the snapping turtle may be a significant agent in the dispersal of the seeds of such aquatic plants.

East Twin Lake.—This lake has an estimated area of forty acres (Henshaw, 1931) and a maximum depth of forty feet. The shoreline is partly hilly and wooded and partly swampy. Bottom types are predominantly fibrous and pulpy peat and marl with a little sand at the inlet. The small outlet, Bigelow Creek, flows into Muskegon River. Several cool springs occur in the soft, peaty bottom of the north end of the lake. Shoal areas are extensive at the north and south ends of this body of water. The principal plants are filamentous algae, *Chara*, mosses, potamogetons, *Najas*, *Anacharis canadensis*, *Lemna*, *Spirodela polyrrhiza*, *Ceratophyllum demersum*, *Ranunculus*, *Myriophyllum*, *Polygonum*, *Decodon verticillatus*, *Scirpus*, and *Typha*.

Game and pan fishes collected by me from this lake are largemouth bass, northern rock bass, bluegill, pumpkinseed, yellow perch, and brown bullhead. Common white suckers (*Catostomus c. commersonnii*), several species of minnows, and Johnny darters (*Boleosoma n. nigrum*) and Iowa darters occur. Muddlers (*Cottus*) are present at the outlet.

The turtle species are the mid-western painted turtle, snapping turtle, Blanding's turtle, map turtle, and the musk turtle (listed in order of decreasing abundance). Particularly favorable to the turtle population of this lake are the facts that the lake is private and well-removed from travelled roads; that several springs in the soft bottom at one end and a tributary trout stream furnish excellent winter quarters; that extensive shoal areas provide for foraging; and that the lake is seldom fished and thus presumably has a very large fish population.

Twenty-five snappers available for food study were collected in 1938

between July 11 and 27, and on August 16 and 17. These turtles ranging from 180 to 374 mm. averaged 263.8 mm. (10.3 inches) in length.

Game and pan fishes assume a considerable importance by volume (60.9%) in the stomachs. By numbers, however, the average, including those in both the stomachs and in the colons, is less than one and a half such fish per turtle for the feeding period represented by the sample. As in other series, it was impossible to determine whether the fishes (predominantly centrarchids) present in colon contents were dead or alive when taken. The yellow perch, bluegills, and pumpkinseeds found in the stomachs were apparently alive and healthy when eaten. Aquatic plants make up the balance of the food in the stomachs and almost all of that in intestines.

River-mouth lakes. — Specimens from Muskegon and White Lakes are grouped together. These are ecologically very similar and good-sized bodies of water situated near Lake Michigan at the mouths of the two large rivers whose names they bear. They have extensive areas of marsh, and sand and silt shoals. Considerable shoreward expanses are underlain by quantities of water-logged mill waste and many "dead-heads." The mill waste, consisting of long strips of bark and wood trimmings dumped irregularly on the bottom, abounds with crevices and provides a favorable habitat for crayfish, snails, and other invertebrates, which are particularly abundant. Aquatic vegetation is plentiful in the shallower water not too much exposed to wave action.

Seven snappers from White Lake and nine from Muskegon Lake, collected in late August and September contained food in thirteen stomachs and in all colons. The average length of fourteen individuals measured is 228 mm. (9.0 inches), ranging from 144 to 321 mm.

As in Sherman Lake, the food of the snappers from these river-mouth lakes shows game and pan fishes to comprise an unusually high proportion (67.6%) of the food in stomachs. The species taken include bullheads, yellow perch, largemouth bass, bluegills, and pumpkinseeds. It was impossible to determine the origin, as carrion or otherwise, of the fishes in the colons, most of which were represented only by traces. Counting all the game fish represented in stomachs and colons the average is very little more than one per turtle. Owing to the extensive water area it is doubtful that such an incidence in the food of the snapper offers any occasion for concern to the sportsman or to commercial fisheries.

A seven-inch bluegill with a No. 6 fish-hook firmly lodged in its hyoid region was found in the stomach of a turtle 321 mm. long; the injury suffered by the bluegill may have been the direct cause of its capture.

As might be expected from their abundance in these lakes, crayfish are represented in larger proportions than anywhere else in my findings, both in stomachs (22.3% by volume, 53.8% by frequency) and colons (35.3% by volume, 100.0% by frequency). As a result of this abundance of crayfishes and of game fishes in the food, aquatic vegetation is present proportionately less, comprising the balance of the food for each set of organs. The principal

plants found were filamentous algae and the duckweeds, *Lemna trisulca* and *Spirodela polyrhiza*.

Non-trout streams.—Nineteen turtles containing food were collected during summer months from eleven non-trout streams. Eleven of these specimens ranged from 65 to 317 mm. and averaged 218 mm. (8.6 inches) in length.

The entire volume (19.3%) of game and pan fishes in the stomachs was made up by a yellow perch and a smallmouth bass in one turtle. Including all such fish present, even those in the colons which occurred as traces and may have been carrion when taken, only about one out of every three turtles showed evidence of having eaten game species. Fish recognizable as carrion were a rock bass and a bluegill. In this series crayfish are of proportionately greater importance, which may be due to a generally greater abundance per unit area in stream than in lake habitats, excepting such river-mouth lakes as previously cited.

Trout streams.—Only six specimens were secured from waters of this ecological type during the summer months. The snapping turtle population is doubtless lower in such streams than for warmer, non-trout streams of comparable size, and little attempt was made to secure specimens from this habitat.

The high proportion of crayfish (87.0% of the bulk in stomachs) in the food of these snappers corresponds to the fact that crayfish are probably the most readily available food in trout streams. On the basis of the numbers contained in the stomachs only, the five turtles averaged a little more than four crayfish each. In the one colon (turtle 279 mm. long) that contained crayfish, there were remains of a large, unascertained number with a volume of 450.0 cc. The nine-inch trout found in one stomach may have been taken alive or as carrion.

Fish hatcheries.—Twenty-one summer taken specimens containing food (Table 3) were available for study from eight hatcheries in the Lower Peninsula. The average size of twelve measured specimens ranging from 51 to 294 mm. is 210 mm. (8.2 inches).

Unusually large numbers of fishes are concentrated in ponds and raceways at fish hatcheries and rearing stations. Since it is generally assumed that such concentrations create an increased vulnerability of the fish to their predators, it is noteworthy that the snappers took game fishes in no greater amounts than did the turtles collected from some natural waters. The average for turtles from fish hatcheries is approximately one game fish for each three turtles. Considering the possible benefit derived from the destruction of the runts and diseased fishes and of numbers of predacious insects, the predation of snapping turtles at hatcheries under certain conditions seems to be innocuous.

Where fish are being removed from hatchery ponds by fyke nets or other means that tend to concentrate them in an enclosure also accessible to turtles, where they are extremely crowded in raceways, or where eggs of pond-fishes are placed on trays in rearing ponds, snapping turtles can not be tolerated. The limitation of production in fish cultural establishments by this species is, however, less than has been supposed.

TABLE 3.—THE FOOD OF THE SNAPPING TURTLE AT FISH HATCHERIES.

Based on eighteen stomachs containing 1,049.3 cc. of food and on ten colons containing 336.7 cc. of food.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game and pan fishes	54.5	27.8	1.1	10.0
Forage fishes	26.9	16.7	0.4	30.0
Unidentified fishes	3.9	22.2	0.3	20.0
Frogs and toads	1.2	16.7	0.5	40.0
Crayfishes	8.0	61.1	41.6	80.0
Insects	1.0	38.9	1.9	80.0
Miscellaneous animals*	0.4	5.6	0.4	40.0
Cryptogams	2.1	27.8	6.1	40.0
Phanerogams	0.4	27.8	10.6	40.0
Vegetable debris	1.6	16.7	37.1	70.0

* Includes remains of a meadow mouse and a muskrat in one stomach and water mites and a scud in one colon and snails in four colons.

ANNOTATED LIST OF ITEMS IN THE FOOD OF 323 SNAPPING TURTLES

In the following list the numbers of specimens of each food item as determined by actual count (when feasible) are given with detailed identifications of the substances taken. It was sometimes impracticable or impossible to determine the number of individuals composing some of the food items, in which case notes on relative abundance are entered. Excepting seeds, plant materials are of necessity recorded in this fashion.

Game and pan fishes.—Of two trout found in stomachs, one was identifiable as the eastern brook trout (*Salvelinus f. fontinalis*). Fourteen bullheads included 5 northern brown bullheads and 3 northern yellow bullheads. In the pike family, 6 individuals could be recognized of which 4 were mud pickerel (*Esox vermiculatus*) and 1, a northern pike. Eighteen yellow perch occurred. The sunfish family was represented by 264 individuals distributed as follows: northern smallmouth bass, 5; largemouth bass, 6; common bluegills, 43; pumpkinseeds, 45; northern rock bass, 1; and miscellaneous centrarchids, 164. Of the game and pan fishes previously enumerated, the brook trout, 3 smallmouth bass, 2 largemouth bass, 13 bluegills, and 28 pumpkinseeds had been eaten at the fish hatcheries.

Forage fishes.—Six suckers were recognized. Of 33 minnows, 17 were western golden shiners (*Notemigonus crysoleucas auratus*), 1, a common shiner (*Notropis cornutus*), and 1, a northern blacknose shiner. Eight mudminnows (*Umbra limi*), 2 Johnny darters (*Boleosoma nigrum*), 2 Iowa darters, and 1 fantail (*Catnotus f. flabellaris*) complete the list. Of these, 1 sucker, 14 golden shiners, 1 common shiner, and 5 other cyprinids were contained in snappers collected at fish hatcheries.

Fish eggs.—A large number (20,520) of eggs, presumably bluegill, were found in the stomachs of three snapping turtles.

Other vertebrates.—Vertebrates other than fishes were: mudpuppy (*Necturus maculosus*), 1; American toad (*Bufo americanus*), 1; bullfrog (*Rana catesbeiana*), 3; pickerel frog (*Rana palustris*), 1; unidentified frogs or toads, 11; musk turtles, 10; common snapper, 1; Blanding's turtle, 1; common mallard (*Anas p. platyrhynchos*), 1; blue-winged teal (*Querquedula discors*), 1; Florida gallinule (*Gallinula chloropus*), 1; unidentified birds, 4; muskrat (*Ondatra zibethica*), 2; eastern meadow mouse (*Microtus p. pennsylvanicus*), 1.

Carrion.—The following animal species were identified as carrion and therefore have not been given elsewhere in this list: bluntnose minnow, yellow perch, largemouth bass, northern rock bass, common bluegill, black crappie (*Pomoxis nigro-maculatus*), exuvium of the blue racer (*Coluber constrictor flaviventris*), musk turtle, and European starling (*Sturnus v. vulgaris*).

Miscellaneous invertebrates.—Freshwater sponge material, an earthworm, a tubificid, and four leeches were in stomach contents.

Crustaceans.—Several scuds (*Hyaella knickerbockeri*) and other amphipods were found. Crayfishes (*Cambarus*) not identified to species numbered 146; others were: *C. virilis*, 127; *C. immunis*, 21; *C. propinquus*, several; *C. robustus*, 1; and *C. diogenes*, 6.

Water mites.—Several species of water mites were present as follows: *Diplodontus despiciens*, few; *Limnesia undulata*, 2; *Unionicola crassipes*, 1; *Neumania ovata*, 1; *Neumania armata*, 3; *Neumania semicircularis*, few; *Neumania* sp., 1; *Koenikea wolcotti*, 1; *Forelia liliacea*, 1; *Piona reighardi*, 2; *Piona pugilis*, 5; *Piona wolcotti*, 1; *Piona* sp., 2; *Mideopsis orbicularis*, 1; *Arrenurus infundibularis*, 2; *Arrenurus manubriator*, 1; *Arrenurus marshallae*, 5; *Arrenurus megalurus*, few; *Arrenurus megalurus intermedius*, 2; *Arrenurus wardi*, 2; *Arrenurus falcicornis*, 2; *Arrenurus* sp., 27.

Insects.—Insects of the following groups were present: Orthoptera, 1; *Corydalid* larva, 1; *Ephemerella bicolor* nymphs; *Caenis* nymphs; Ephemeroptera nymphs; *Anax junius* nymph, 1; *Libellula* nymph, 1; *Leucorrhinia* nymph, 1; other anisopteran nymphs; *Enallagma* nymphs, 3; other zygopteran nymphs; miscellaneous odonate nymphs, 4; Corixidae, 5; *Plea striola*, 1; *Ranatra*, 2; *Lethocerus*, 6; *Benacus*, 2; *Belostoma*, 10; Belostomatidae, 12; Gerridae; other Hemiptera, 1; Homoptera, 1; *Haliphus*; *Peltodytes* larvae; Haliplidae, 2; *Aciurus*, 1; Dytiscidae, 90; Gyrinidae, 4; hydrophilid larvae and adults, 32; Elmidae, 1; Chrysomelidae, 2; Curculionidae, 1; other beetle larvae and adults; hydroptilid larvae, 11; larvae of *Phryganea*; leptocerid larvae; other trichopterous larvae; Tipulidae, 8; chironomid larvae and pupae; ceratopogonid larvae; larvae of *Stratiomyia*, 1; several unidentifiable insects.

Snails and clams.—Identified were: *Lymnaea emarginata*; *Lymnaea* sp.; *Helisoma trivolvis*; *Helisoma antrosom*; *Helisoma campanulatum*; *Helisoma* sp.; *Gyraulus parvus*; *Gyraulus hirsutus*; *Gyraulus* sp.; *Planorbula armigera*; *Planorbula* sp.; *Physa sayii*; *Physa elliptica*; *Physa* sp.; *Campeloma* sp.; *Valvata*

tricarinata; *Valvata sincera*, 10; *Bithynia tentaculata*, 116; *Amnicola limosa*; *Amnicola integra*; *Amnicola lustrica*; *Amnicola* sp.; *Sphaerium striatinum*; *Sphaerium* sp.; *Pisidium abditum*; *Pisidium* sp.

Cryptogams.—In addition to a small amount of moss the following algae were found: *Oscillatoria princeps*; *Oscillatoria* sp.; *Lyngbya*; *Anabaena*; *Nostoc*; *Tolypothrix*; *Ulothrix*; *Coleochaete nitellarum*; *Cladophora glomerata*; *Cladophora* sp.; *Rhizoclonium hieroglyphicum*; *Rhizoclonium* sp.; *Pithophora varia*; *Oedogonium*; *Hydrodictyon reticulatum*; *Vaucheria*; *Mougeotia*; *Zygnema*; *Scenedesmus scutiformis*; *Spirogyra crassa*; *Spirogyra* sp.; *Chara*; *Nitella*.

Phanerogams. Flowering plants represented were: *Typha*; *Potamogeton*; *Najas*; *Anacharis canadensis*; *Vallisneria spiralis*; various Gramineae; *Phragmites communis*; *Scirpus*; *Peltandra virginica*; *Spirodela polyrhiza*; *Lemna trisulca*; *Lemna minor*; *Lemna* sp.; *Wolffia*; Lemnaceae; *Salix*; *Ceratophyllum demersum*; *Nuphar advena*; *Nymphaea odorata*; *Nymphaeaceae*; *Brasenia Schreberi*; *Ranunculus*; Rosaceae; *Acer*; *Myriophyllum*; *Cornus Amomum*; *Cornus* sp.; *Utricularia*; Compositae; *Bidens*; *Lycopersicon esculentum*.

SUMMARY AND CONCLUSIONS

A summary of the food contained in 173 stomachs and 261 colons of 281 snapping turtles collected from natural waters is given in Table 4. The volumetric relationships of items in the stomachs are shown in Fig. 7. The data for the twenty-one specimens from Wintergreen Lake are not included since this lake is abnormal in its unusually high waterfowl population. The twenty-one specimens from fish hatcheries are also omitted.

Considering only the stomach contents, game and pan fishes, carrion and plants appear as the most important foods of this turtle. On the basis of stomach contents about one-third of the food of the snapping turtle in Michigan is composed of game and pan fish. Another third is composed of vegetable matter, almost entirely the leaves and petioles of aquatic plants, eaten by three out of every four individuals. The remaining third is largely the remains of

TABLE 4.—The Food of the Snapping Turtle in Natural Waters in Michigan.

Based on 173 stomachs containing 4,133 cc. of food and on 261 colons containing more than 8,855 cc. of food. The organs are from 281 turtles collected on seventy-one lakes and eleven non-trout and six trout streams.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game and pan fishes	34.2	32.4	2.1	51.7
Forage fishes	0.3	5.8	0.4	10.3
Unidentified fishes	0.9	12.7	2.1	35.2
Other vertebrates	1.1	2.3	1.1	7.2
Carrion	19.6	6.4	1.3	2.7
Invertebrates	7.8	49.7	23.9	82.4
Vegetable matter	36.2	74.6	69.2	93.5

dead animals but includes significant quantities of crayfish, snails, and insects.

If one regards the results of the analyses of colon contents only, about one-fourth of the food appears to be composed of invertebrates, principally crayfish, and three-fourths to be composed of aquatic vegetation.

If the remains of all the game and pan fishes found in the food of the snappers studied from wild waters were of fishes that were alive and healthy when taken, 302 turtles would have accounted for 275 live fishes, over the period of time represented by the remains in the digestive tract. Since this figure must be considerably reduced by the proportion of specimens taken as carrion the minimal significance of this species to game and pan fish populations seems apparent. It seems a conservative estimate that on the average not more than one game or pan fish is eaten per day by the individual snapping turtle.

To interpret in another way the data on numbers of game fish eaten by snapping turtles in natural waters, still assuming all fish encountered to have been alive and healthy when taken, the 186 stomachs that contained food averaged approximately five-tenths of a game and pan fish each, whereas the 278 colons with food averaged seven-tenths of such a fish each. Recalling that the contents of each stomach probably represented a partial "meal," and that each colon probably includes the remains of several feedings, we may assume that the contents of 186 stomachs and 278 colons (of 302 specimens from natural waters) approximately represent 454 sample "meals." In this large number of meals, the creel fish average six-tenths of an individual per turtle. This interpretation probably offers the truest picture of predation on game fishes by snapping turtles.

Most game and pan fishes eaten by the snappers were less than legal size, and such smaller fishes are much more abundant in nature than those of legal size. Populations of snappers were estimated by the mark and recapture method in Wolf and East Twin Lakes to approximate two snapping turtles per acre of surface area in these waters. These considerations further minimize the significance of the estimate that each snapper on the average consumes six-tenths of a game fish per feeding. Thus there need be little concern as to the adverse relations of snapping turtles to game fish populations in wild waters.

Since forage fishes are more often abundant in waters than are game fishes, it is surprising to note their fewness in the food of the snappers studied. They averaged about one to every ten of the 462 sample meals. Consequently, this turtle does not appear to have a significant role in the current decline of forage fish populations, nor does it seem to compete significantly with game fishes for this type of food.

It is regrettable that more complete information is not available on the relations of this turtle to nesting game and pan fishes, but too few specimens were obtained from the vicinity of spawning beds to afford conclusive data in this respect.

No vertebrates other than fishes were found in sufficient numbers to warrant recommendations that populations of this turtle be reduced. Attack on waterfowl, young or adult, is hardly more than suggested. Despite the local concen-

tration of waterfowl the series of twenty-one specimens from the W. K. Kellogg Bird Sanctuary contained the remains of only four young mallards in a total of some thirty "meals." Recalling that it could not be ascertained whether or not these birds were alive and healthy when taken, the somewhat damaging nature of this evidence is reduced. In 434 meals in natural waters (not including sanctuary and fish hatchery waters), feathers were found three times and remains of a Florida gallinule and a blue-winged teal once each. Contrary to report, there is an extremely low incidence of bird remains in the food of the snapping turtle.

Crayfishes include the greatest number of invertebrates taken. Insects, mollusks, water mites, and a miscellany of other invertebrates, although occurring in large numbers, account for a relatively insignificant proportion of the total food volume. The greatest significance of the feeding habits of the snapping turtle to game and pan fishes may be the competition which they offer for such food, since fishes forage upon many of the same organisms.

The consumption of mollusks by this turtle may be of importance in interrupting the life cycles of certain parasites and thus may have an indirect economic significance.

Vegetable matter is clearly the principal food substance. The extent to which feeding upon aquatic vegetation by snappers may be regarded as harmful or beneficial requires separate consideration for each body of water. As pointed out by Hubbs and Eschmeyer (1938), it may be desirable to control aquatic plants in some circumstances and to encourage their growth in others. Obviously this turtle has some habits that tend to crop and others that may disturb water plants. Other habits may spread them. Plants are cropped by being fed upon and are uprooted by snappers while foraging for other organisms. Spread of aquatic plants is doubtless accomplished by the passage of undigested seeds with feces. Where large amounts of plant materials are eaten, fewer fish and fish-food organisms find their way into the diet of this turtle, so that the effect of feeding on plants may be beneficial to the game and pan fish population.

The considerable importance of carrion in the food of the snapping turtle is suggestive of a desirable service rendered to man by this turtle. Doubtless the snappers eat many dead and dying fishes and other matter that might otherwise form obnoxious litter on resort beaches and elsewhere.

Much time in the field was spent in studying the importance of the snapper fishery for the market (See Clark and Southall, 1920). During the summers of 1937 to 1939 the market demand far exceeded the supply. Trappers found a ready sale for all the turtles caught at wholesale prices ranging from five to eight cents per pound, live weight. These trappers have mobile units and obtain snappers mostly by means of traps made of seine twine on wire hoops with a single funnel-shaped opening (Lagler, 1943). Captured turtles are held and fed in a live-pen until several hundred pounds have accumulated. They are then shipped alive in a barrel or crate to market. The best markets for Michigan turtles are in Chicago and various cities in northern Indiana and Ohio. The greatest demand comes from the restaurant trade, but many turtles are sold to

private individuals. Retail prices range from ten to twenty cents per pound liveweight and twenty to thirty cents dressed.

A trapper and helper operating about five dozen traps in Michigan waters report an average profit of a thousand dollars for each of the last three summers. Others state that revenue derived from this occupation has enabled them to make a living during recent years of economic depression.

The food habits data here presented give some indication of harmful effects of snapping turtles in aquatic communities. Considering also the services rendered to man, it seems best to recommend their conservation, except in waters where special investigation proves them to be undesirable. Conservation measures would help to ensure a sustained yield of these reptiles to professional trappers. The imposition of restrictions on turtle hunters as to minimum sizes to be taken and mesh-size to be used in traps might be desirable. Six inches, measured lengthwise and horizontally through the carapace, should be fixed as the minimum size for this purpose. A three-inch square mesh in traps would almost automatically establish this limit. An eight-inch turtle is about the smallest which has any real market value, although smaller sizes are often taken indiscriminately and shipped. The length-weight relationship in the snapping turtle, useful in determining regulatory measures, is given in another report (Lagler and Applegate, MS).

CLEMMYS GUTTATA (Schneider)—Spotted Turtle

Range and Size.—The spotted turtle is uncommon in Michigan and is not recorded from the northern half of the Lower Peninsula; the most northerly record is from Lake County. The species averages less than 127 mm. (5.0 inches) in carapace length.

Habitat and Habits.—Many authors consider this small turtle to be essentially aquatic, inhabiting small waters. A few suggest that it may have terrestrial habits at certain seasons of the year (in addition to the time of egg-laying). The spotted turtle is given to basking in the sun on objects out of the water, as are the map, painted, and Blanding's turtles.

Extensive field work in the normal haunts of the painted, Blanding's, musk, and snapping turtles failed to yield any specimens of *Clemmys guttata*. It therefore seems logical to assume that the species may be common only in restricted localities within its range in Michigan.

Food and Feeding Habits.—Excepting the work of Surface (1908), no extensive studies of the food of this species appear in the literature. Summarizing the findings of earlier workers, however, one discovers the following items reported as food of spotted turtles: frogs, tadpoles, insects and their nymphs and larvae, earthworms, mollusks, crickets, grasshoppers, plant stems and leaves, dead fish, and birds.

Surface (1908) studied the contents of twenty-seven stomachs of this species and found: vegetable matter in 3; annelid worms in 1; mollusks in 3; crustaceans in 8; myriapods in 1; spiders in 2; and insects (principally Coleop-

tera, Odonata, and Diptera) in all 27. Of interest is the fact that Surface encountered no vertebrates in the food of this turtle.

SUMMARY AND CONCLUSIONS

It seems rather clear, from the food and habitat preferences stated by other workers, and because of its uncommon occurrence, that the spotted turtle can be of no economic concern, especially in fish management, in Michigan.

CLEMMYS INSCULPTA (Le Conte)—Wood Turtle

Range.—The wood turtle was not known from Michigan prior to 1915 (Thompson, 1915a). Since that time it has been recorded from several counties in the northern two-thirds of the Lower Peninsula and in the Upper Peninsula. It remains unknown from the three southern tiers of counties across the state, and from the "Thumb" (Fig. 3). The species in Michigan averages between 178 and 279 mm. (7-11 inches) in carapace length.

Habitat and Habits.—Accounts of the habitat of the wood turtle indicate that the species occurs on land for most of its activities excepting mating or hibernation. The best accounts of the natural history of this species are those of Wright (1918) and Babcock (1919).

Food and Feeding Habits.—Many workers have published notes on the food and feeding habits of this species. Verrill (1863: 196) reported discovering specimens feeding on the leaves and scapes of dandelions (*Taraxacum densleonis*). Smith (1883: 659) observed that they feed on low field blackberry and other vegetables. Allard (1909: 453) watched a specimen feed greedily on mullein leaves (*Verbascum thapsus*), common sorrel (*Rumex acetosella*), and strawberries. Netting (1936) also found a specimen eating strawberries. Babcock (1919: 406) states that the species is omnivorous, but shows a distinct partiality for vegetable food, especially berries. Morgan (1930: 402) likened the terrestrial feeding habits of the spotted turtle to ground-feeding birds: blackberries, partridge berries, and mushrooms. She noted, however, that in water they live on a diet of small aquatic animals. Surface (1908: 162-163) has made the only detailed study of the food of this species. He found that 76 percent of twenty-six specimens that contained food had eaten vegetable matter whereas 80 percent had eaten animal matter. Among those that had eaten animal tissue seven had taken mollusks, and fourteen had eaten insects.

Netting (1927: 4) offered an explanation of the incidence of bird remains in the specimens studied by Surface (*loc. cit.*). He wrote:

The Wood Turtle (*Clemmys insculptus*) is so largely herbivorous and so mild tempered that it seems unlikely that it ever drags down and eats living birds. The bird remains which Surface reports (1908: 192) from the stomach contents of this species may have been those of a bird which the turtle had found floating dead on the water. Furthermore, after the spring mating season the Wood Turtle is largely terrestrial.

The habitat preferences of the wood turtle, its food habits, and its relative scarcity in Michigan, all have indicated that the species can have little signifi-

cance from the viewpoint of fish management. Consequently no special effort was made to obtain specimens.

Food in the digestive tracts of nine adult specimens collected in Michigan (Fig. 3) was as follows:

- (1) 2.8 cc. of filamentous algae and willow leaves (*Salix*).
- (2) 11.0 cc. of plant material (mostly algae) and insect remains including 3 blackfly larvae.
- (3) 60.0 cc. of filamentous algae including several caddis larvae (Trichoptera) and many small mollusks.
- (4) 10.6 cc. of remains of a beetle, a tadpole (*Rana*), and a snail (*Helisoma*).
- (5) 37.5 cc. of a bluegill and 46.5 cc. of larvae of caddisflies (Limnephilidae) and their houses.
- (6) 2.4 cc. of food remains including 14 *Brachycentrus* larvae, 2 limnephilid larvae, 1 neuropteran larva, a snail, and a leaf fragment.
- (7) 2.1 cc. of limnephilid larvae (6) and their houses and a trace of a leaf.
- (8) 4.8 cc. composed of 5 oligochaete earthworms, 1 adult of Hymenoptera, moss, willow leaves, leaves of grass, and vegetable debris.
- (9) 1.8 cc. comprised by remains of 1 trout (Salmonidae), insects, and vegetable debris including some algae.

SUMMARY AND CONCLUSIONS

The analysis of the food of nine Michigan specimens confirms both the more extensive study by Surface (1908), and the natural expectation from its predominantly terrestrial habits, that this turtle can be of no concern to fish management.

EMYS BLANDINGII (Holbrook)—Blanding's Turtle

Range and Size.—In the Lower Peninsula of Michigan, Blanding's turtle is known from most counties and probably occurs over all of the area. In the Upper Peninsula it has been recorded from only one locality, in Marquette County (Fig. 4).

Although individuals may attain a size of 236 mm. (9.3 inches, greatest length through the carapace of an adult male in my collections), 200 mm. (eight inches) is the average size of forty-four adult males and females selected at random from among the specimens which I studied for food. Ruthven (1927) considered 230 mm. as an unusually large size for this species in Michigan.

Habitat and Habits.—Published accounts on the habits and the habitat preferences of Blanding's turtle are few, as compared with the information on the other turtles which occur in the state. Some authors (Blanchard, 1928; Thompson, 1911; Hankinson, 1917; etc.) report finding this turtle in water;

others (Potter, 1920; Garman, 1892; Hay, 1883; etc.) report finding it on land. Schmidt and Necker (1935) state that it is abundant in sloughs during the spring and on land in the summer and fall. In my field studies of Blanding's turtle in Michigan, no attempt was made to learn of the terrestrial habits. Except for a few females taken along highways not far from water in late spring and early summer during the nesting season, all specimens of this turtle which I have observed or collected in Michigan were in aquatic habitats: lakes, ponds, creeks, rivers, and hatchery ponds. In such places they are commonly associated with musk, snapping, painted, and map turtles.

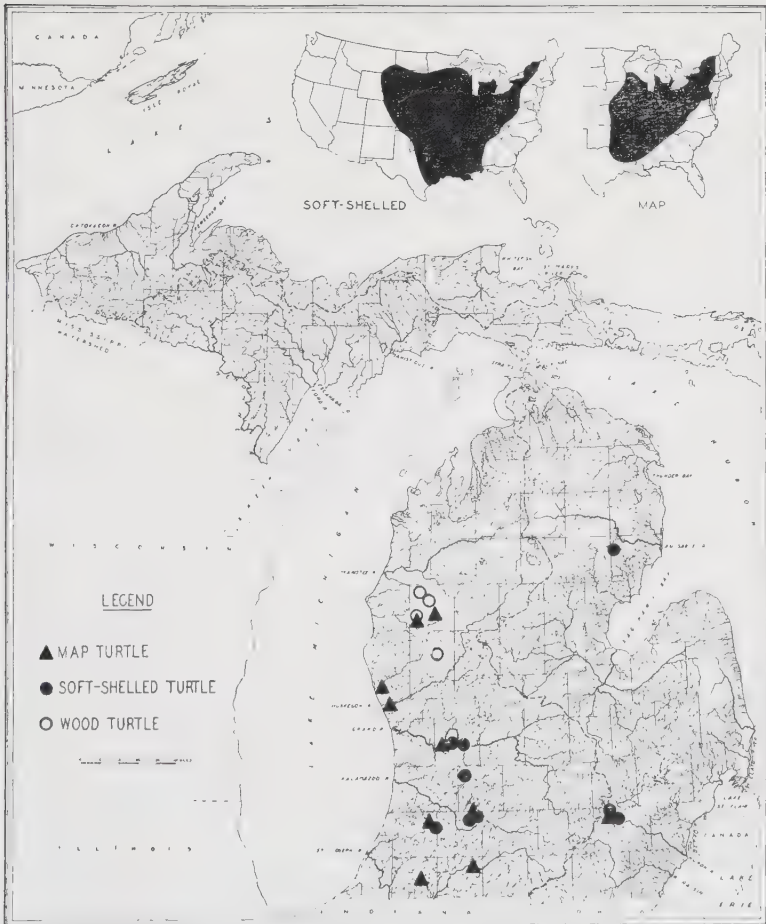


Fig. 3. Locations from which wood, map, and soft-shelled turtles were studied and range of the map and soft-shelled turtles in the United States.

Notwithstanding the restriction of my work to the habitats listed, I am inclined to feel that in Michigan, at least, this species is much more aquatic than the literature might lead one to believe. As evidence of the aquatic propensities it may be mentioned that during the months of May through September, in the summers of 1937 and 1938, forty-seven specimens were taken in turtle traps from Wolf Lake, Van Buren County, and fifty-two were collected by this means in East Twin Lake, Newaygo County. In addition, they are fairly adept swimmers and are also given to basking on objects out of, though near, the water; they retreat to the water at the slightest disturbance and usually move toward the drop-off. Conant (1938) has observed specimens moving about under the ice in captivity and hibernating in this environment but also records hibernation on land under circumstances similar to those I have observed for the snapping turtle.

Food and Feeding Habits.—Specimens in the reptile pit at the University Museums have been observed to take ground beef into the water before swallowing it. They have not been seen to swallow food out of water. Captive specimens in tanks in the laboratory have soon learned to take ground beef from the hand and have always retired under water before swallowing. Carl L. Hubbs has had live minnows captured by members of this species in small aquaria. Regarding feeding habits, specimens in a large exhibit pool at the State Fish Hatchery near Oden, Emmet County, have been seen rooting about under the detritus on the bottom of the pond in two to three feet of water. Although crayfishes and aquatic insect larvae were present in this pond, no captures of these organisms were observed. In this type of foraging activity the head was used to turn over small flat stones on the bottom and the head and claws were employed to enlarge and explore recesses under bulky objects. That they may at least sometimes feed in moderately deep water was shown by an observation of two individuals which were foraging at night on the bottom in water seven feet deep in Wolf Lake, Van Buren County.

My food studies of Blanding's turtle are based on sixty-seven specimens which contained food either in the stomachs or colon or in both. These turtles were obtained from seventeen lakes, two non-trout streams, one trout stream, and three fish hatcheries during the months of May through September mostly in 1937 and in 1938 (Fig. 4). Enough specimens with food were obtained in Robinson and East Twin Lakes to warrant a brief separate consideration of the material from each of these bodies of water. Individuals from many other lakes have been combined into one group, those from fish rearing stations into another, and those from non-trout streams into yet another. For each of these groups the findings are discussed individually. In the annotated list are given details of the numbers and kinds of the items eaten, and in Table 5, a summary of the food of this turtle for all natural habitats.

Robinson Lake.—This small, shallow lake in Newaygo County has an abundance of aquatic vegetation growing from a very soft bottom. The eleven Blanding's turtles studied for food from this water were collected on August 30, 1938. Their average length is 168 mm. (6.6 inches), ranging from 119 to

190 mm. Four stomachs contained no food but some food was present in each of the eleven colons.

In Robinson Lake, the principal foods of this turtle as seen by volume in stomachs are very definitely crayfishes (29.9%), aquatic insect larvae (35.1%), and fish carrion (24.7%). The same holds for the food as seen in the colons, except that here the remains of crayfishes (43.0%) and those of insects (51.7%) compose practically all of the food. The dead fishes eaten were of less than legal size and apparently had been returned to the water by anglers. The food of these specimens is very similar to that of two snapping turtles

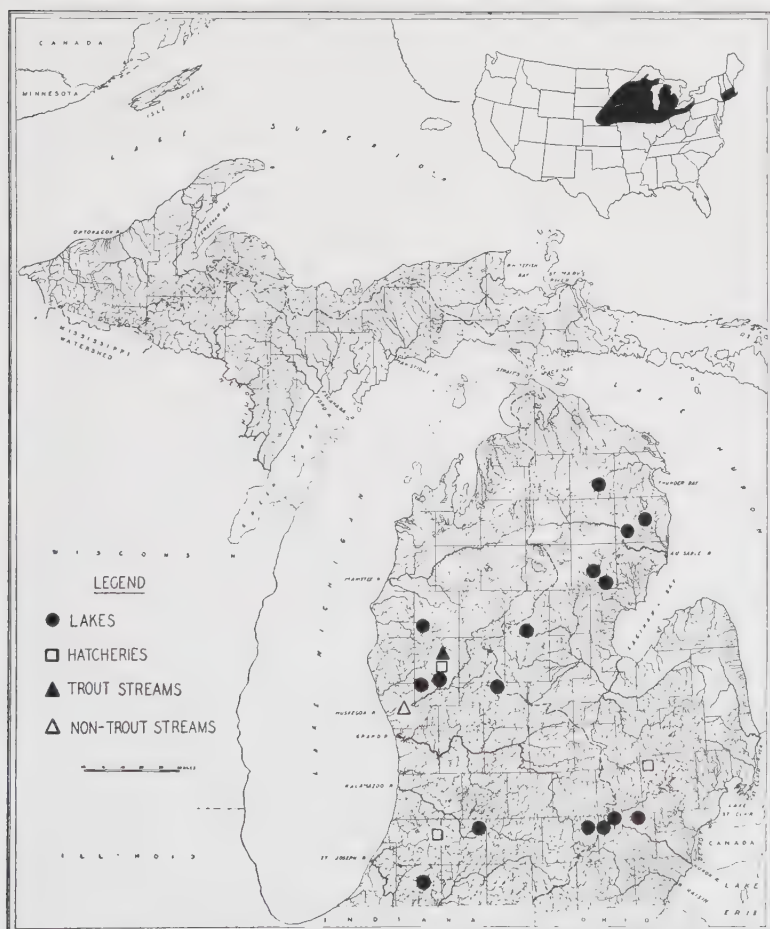


Fig. 4. Types and locations of waters from which Blanding's turtles were studied and general range of the species in the United States.

collected from this lake at the same time. The snappers, however, had eaten a little more aquatic vegetation than had the Blanding's turtles. The principal effects of the Blanding's turtles on the game fishes of this lake at this time appeared to be in competition for food.

East Twin Lake.—A brief description of the biological and physical features of East Twin Lake has previously been given (p. 272). Eleven of the Blanding's turtles which contained food for analysis from this body of water were collected on May 19-20, 1937, one on July 12-13, 1938, and another on August 16-17, 1938. These thirteen turtles averaged 212 mm. (8.3 inches) in carapace length, ranging from 181 to 236 mm. Forty-one additional individuals of the species which were trapped in this lake were measured, marked for future recognition, and released as a part of population-density and growth-rate studies.

The two principal food items by volume in the stomachs of the Blanding's turtles from this lake, as for Robinson Lake, were obviously crayfishes (52.1%) and aquatic insect larvae (41.4%). The contents of the colons by bulk was 69.3 per cent crayfish remains and 26.5 per cent insects. No carrion was found, perhaps because most of the turtles were taken before the fishing season opened and before the spawning season for centrarchids was under way. Aquatic vegetation, generally less abundant in this lake than in Robinson Lake, occurred in lesser amounts in the food of these specimens than in those from Robinson. Again the sole possible significance of the food relations to game fishes appears to be in competition for food.

Miscellaneous lakes.—The food data for Blanding's turtle from lake habitats in general is based on thirty-two specimens taken during summer months from fifteen additional lakes widely distributed over the Lower Peninsula. The average length of twenty-eight of these specimens measured is 199 mm. (7.8 inches), ranging from 110 to 229 mm. The information from the food contained in specimens in this sizeable series substantiates that of smaller series for Robinson Lake and for East Twin Lake. The data for the two individual lakes is very similar to those of this larger series; this may be taken to indicate an adequacy of the samples. As previously indicated, this turtle is apparently of greater significance to game fishes as a competitor for food than as a predator. In the stomachs crayfishes compose 69.9 per cent of the food and in the intestines, 68.1 per cent. Insects comprise 10.6 per cent of the stomach contents and 20.8 per cent of those in intestines. Some carrion (7.2%) was found in the stomachs.

Non-trout streams.—Although Blanding's turtle is very common in the quiet, marshy areas of several non-trout streams such as the Kalamazoo and Huron Rivers, only four specimens were obtained for study from these habitats. Three contained food solely in their stomachs, and one contained 0.1 cc. of vegetable debris in the colon only. Remains (61.1% by volume) of an unidentified bird encountered in one turtle apparently were carrion when taken. There is a duck pen near the place where this specimen was collected and it is probable that the remains represent a bird recently killed by some predator.

Crayfishes (13.5%) and forage fishes (mostly minnows; 23.9%) made up most of the remainder of the food in these three stomachs.

In contrast to the food of the three specimens (from non-trout streams) in which no game fishes appeared, one eight-inch specimen from the White River in Newaygo County (a trout stream) was found by J. C. Salyer, II, to contain in its stomach fifteen brown trout averaging three inches in length with a total volume of 57.9 cc. Also present in the stomach were two Johnny darters, two snails, and one crayfish (*Cambarus virilis*). The colon held traces of trout, caddisfly larvae, and snail remains. Although this individual was collected in the natural stream, it is possible that it had recently fed in the raceways of the adjacent trout rearing station. This would explain the number of trout present; brown trout of the size taken were being cultured in the raceways at this time.

Fish hatcheries.—From fish hatcheries, as from non-trout streams, the series of specimens available for food study is too small to be of conclusive significance. The six specimens whose food was analyzed were collected during the months from June through August.

The food in the colon of one specimen, the stomach of which also contained food, was composed of 65 per cent insect remains and 35 per cent vegetable debris.

Although game fishes (87.5%) made up most of the volume of the stomach contents only two of the six specimens contained such fishes, six in the stomach of one individual and one in that of another. These two turtles were from the trout raceways of the White River Rearing Station. The remaining three specimens, from bluegill and forage-fish ponds, had not eaten any of the fishes being propagated. Because of lower concentration, fish were probably somewhat less available (and thereby less vulnerable) in these ponds than in trout raceways. Crayfishes composed 6 per cent of the food of these individuals.

Carl L. Hubbs has demonstrated (unpublished data) the ability of Blanding's turtle to capture and eat several minnows in a short period of time in a forty-gallon aquarium. The conditions of his experiments were very much like the conditions in the narrow confines of raceways. This evidence and that from the food analyses seems to indicate that this turtle should be removed and excluded from fish rearing waters. Means by which this may be accomplished have been described by Lagler (1939).

ANNOTATED LIST OF THE ITEMS IN THE FOOD OF SIXTY-SIX BLANDING'S TURTLES

Game fishes.—Seven eastern brook trout (*Salvelinus f. fontinalis*) had been eaten by one of the turtles from a fish hatchery. Other game fishes eaten included: 2 yellow perch, 2 sunfishes, and 3 centrarchids.

Forage fishes.—Six muddlers (*Cottus bairdii*) had been eaten from non-trout waters. A brook stickleback (*Eucalia inconstans*) was found in a Blanding's turtle from East Twin Lake that had apparently been feeding in or near the trout stream tributary to this lake.

Fish eggs.—Unidentifiable fish eggs numbering 111 were found in the stomach of a specimen from East Twin Lake.

Birds.—Unidentifiable fragmentary remains of two birds were found in one turtle each. It could not be determined whether or not these birds had been killed by the Blanding's turtles but it seemed unlikely that they had been.

Carrion.—Identified as carrion were the remains of a yellow perch and of another fish in one turtle each.

Leeches.—Hirudinea were represented by two individuals.

Crustaceans.—Twenty scuds (*Gammarus*) were found. Crayfishes (*Cambarus*) numbered 147; some were referable to *C. virilis* (36) and to *C. propinquus* (67).

Insects.—Insects, in addition to unidentifiable and fragmentary remains, were represented by a large variety of kinds and in considerable numbers as follows: *Hexagenia* nymph, 1; *Anax junius* nymphs, 27; *Aeschna* nymphs, 20; *Epicordulia princeps* nymphs, 4; *Libellula* nymphs, 176; *Sympetrum* nymphs, 4; *Leucorrhinia* nymphs, 11; *Celithemis elisa* nymphs, 2; *Celithemis* sp. nymphs, 80; unidentifiable dragonfly nymphs, 183; *Enallagma* nymph, 1; damselfly nymph, 1; adults of *Belostoma*, 5; adults of Belostomatidae, 9; *Lethocerus americanus*, 2; adults of *Pelocoris*, 2; *Haliplus* adult, 1; *Dytiscus* adult, 1; *Acilius* adult, 1; other dysticid larvae and adults, 14; hydrophilids, 3; chrysomelids, 1; other beetle, 1; *Neuronia postica* larvae, 2; *Neuronia* sp. larvae, 2; larvae of Leptocerinae, 2; leptocerid larvae, few; limnephilid larvae, 2; caddisfly larvae, several; pyralid larva, 1; lepidopteran larva, 1; larvae of Stratiomyidae, 6; other dipteran, 1.

Snails and clams.—Mollusks were represented by one or a few of each of the following: *Lymnaea palustris*, *Helisoma trivolvis*, *Helisoma antrosum*, *Gyraulus parvus*, *Physa sayii*, *Valvata tricarinata*, *Amnicola*, *Anodonta*, *Sphaerium*, *Pisidium*, and several unidentifiable fragments.

Plants.—Lower plants present were filamentous algae, *Chara*, *Nitella*, and a little moss. Flowering plants identified were *Typha*, *Potamogeton*, *Najas*, *Spirodela polyrrhiza*, *Lemna minor*, *Ceratophyllum demersum*, *Ranunculus*, *Myriophyllum*, *Cornus Amomum* seeds, and *Bidens* seeds.

Vegetable debris.—Fragmentary plant remains not referable to any taxonomic groups were often found.

SUMMARY AND CONCLUSIONS

A summary of the food contained in fifty-one stomachs and forty-one colons of sixty-six Blanding's turtles collected from wild (natural) waters is given in Table 5 and in Fig. 8. The food habits data for the six individuals from fish hatcheries are of course not included. Because of the possibility that the specimen taken from the White River had recently fed at the rearing station, it also is omitted here.

TABLE 5.—The Food of Blanding's Turtle in Natural Waters in Michigan.

Based on fifty-one stomachs containing 195.8 cc. of food, and forty-one colons containing 140.7 cc. of food, from 66 turtles, collected on seventeen lakes and two non-trout streams. One specimen from a trout stream and six from fish hatcheries not included.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Game fishes	1.6	5.9	TRACES	7.3
Forage fishes	2.7	5.9	-----	-----
Fish remains	0.7	7.8	TRACES	7.3
Bird remains	5.6	2.0	1.8	2.4
Carion	4.7	5.9	-----	-----
Leeches	0.1	3.9	-----	-----
Crustaceans	56.6	74.5	60.1	85.4
Insects	21.4	54.9	30.3	68.3
Molluscs	2.6	17.6	0.5	12.2
Cryptogams	1.2	21.6	TRACES	36.6
Phanerogams	0.5	31.4	0.3	29.3
Vegetable debris	2.2	39.2	7.0	51.2

Crustaceans, almost entirely crayfishes, make up about one-half of the food of Blanding's turtles in Michigan. More than one-fourth of the food appears to be insects. Miscellaneous invertebrates and vegetable matter compose the remaining fourth of the food. Though it may be concluded that this species is omnivorous as was found also by Cahn (1937) and by Conant (1938), it is interesting to note how restriction to what may be termed an essentially carcinophagous and insectivorous feeding habit involving hard-bodied food organisms causes a close agreement of figures for stomach and colon contents data (Table 5). This is in marked contrast to what has been shown for the somewhat more omnivorous snapping turtle, in which the contents of the stomach and colon are markedly different.

In the annotated list are recorded the details as to the number and kinds of food organisms encountered in lake and stream habitats and at fish cultural stations. The numerical dominance of the food by crayfishes and insects substantiates the findings as seen in Table 5 and reported for Robinson, East Twin, and other lakes. Regarding the food of this turtle, either the volumetric method or the numerical method of food analysis would have given approximately the same picture. By numbers, however, insects are predominant whereas by volume crayfishes come to the front.

As for other aquatic turtles, it would be desirable to have additional information on the relation of this species to nesting game fishes, particularly to centrarchids. This is suggested by the discovery of 111 fish eggs in the stomach of an individual from East Twin Lake.

On the basis of the specimens studied, it seems that on natural waters the principal significance of Blanding's turtles to fish production is reflected in the diet of aquatic invertebrates which this turtle and fishes have in common.

TERRAPENE CAROLINA (Linnaeus)—Box Turtle

Range and Size.—In Michigan the box turtle is known only on the Lower Peninsula in scattered counties to the south and west of an imaginary line drawn from Detroit to Grand Traverse Bay. The average length of the species is less than 152 mm. (6.0 inches).

Habits and Habitat.—The frequent and usual occurrence of the box turtle on land is common knowledge. Only a few of many investigators who have studied this species mention its occurrence in or near streams, swamps, or small, woodland pools.

The specimens which I have collected in Michigan were found on land, near water. On May 2, 1937, I took two individuals in a pasture about fifty feet from a small stream on low, moist ground which was covered with close-cropped grass in St. Joseph County near Three Rivers. The species is particularly common in the lower grounds of the sandy hill-country in Van Buren County near Alma in the vicinity of the Wolf Lake State Fish Hatchery. In this region it shares a habitat in which the hognose snake (*Heterodon contortrix*) and the blue racer (*Coluber constrictor flaviventris*) are also common. Several specimens have been encountered on the sand dykes between ponds at the hatchery.

Food and Feeding Habits.—Holbrook (1842: 25) recorded that the food of the box turtle is composed of insects, crickets and so forth. Allen (1870: 262) found one that had just eaten half the pileus of a very large *Agaricus*. Latham (1916) and Nichols (1917) also report eating of mushrooms. Abbott (1884: 252) reported the species to be omnivorous, including earthworms and strawberries, dewberries, and windfalls from fruit-trees in its diet. Blatchley (1899: 550) twice surprised adults feeding on ripe "papaws." Cahn (1937: 95) writes that vegetable matter predominates in the food of this species and Conant (1938: 139) has observed it to eat earthworms, grubs, crayfish, fish, frogs, salamanders, meat, lettuce, spinach, cabbage, blackberries, blueberries, bananas, tomatoes, several species of fungi, etc., and carrion such as dead birds or amphibians.

Surface (1908: 177) has made the only detailed laboratory study of the food of the box turtle. He analyzed the food for forty individuals and found that in 62 per cent of those containing food vegetable matter was present, in which berries and seeds were conspicuous. Eighty per cent contained animal material. Prominent among the animals identified were snails in fourteen individuals, grasshoppers in seven, moths in nine, and beetles in ten.

SUMMARY AND CONCLUSIONS

It is apparent from accumulated knowledge that this omnivorous and essentially terrestrial turtle can be of no concern in fish management. The idea that it might be a liability in truck or flower gardens, suggested by other workers, is not supported by observation.

GRAPTEMYS GEOGRAPHICA (LeSueur)—Map Turtle

Range and Size.—The map turtle in Michigan is limited in its distribution approximately to the southern half of the Lower Peninsula, although it is unknown from several counties within this area (Fig. 3). The species attains a size as large as 253 mm. (10.0 inches). The average length through the carapace of twenty-one of the specimens studied for food is 157 mm. (6.2 inches), ranging from 91 to 229 mm.

Habitat and Habits.—Many workers have published information on the habitat of the map turtle in various parts of its range such as "lakes" (Conger, 1920; Cahn, 1937; Conant, 1938; Garman, 1892; Gloyd, 1928; Newman, 1906), "rivers" (Thompson, 1915b; Cahn, 1937; Conant, 1938; Garman, 1892; Henshaw, 1904; Morse, 1904), "sloughs" (Cahn, 1937) and "flood-ground pools" (Garman, 1892).

I have seen this preeminently aquatic species basking on logs, two and three deep, with mid-western painted turtles, in sloughs and backwaters of the St. Joseph River near Colon. It is a common species in the quiet waters of the Huron River near Ann Arbor, and it inhabits river-mouth lakes such as White and Muskegon Lakes where I have trapped specimens. The map turtle was found associated with the musk, snapping, Blanding's, mid-western painted, and soft-shelled turtles in many lakes, large and small, in the southern part of the state.

Food and Feeding Habits.—No detailed food studies of the map turtle have been reported; several records, however, exist. Garman (1890: 91) found the food to consist exclusively of mollusks, in young specimens consisting of *Valvata tricarinata* and other thin-shelled species, in adults of larger and thicker shelled forms. Newman (1906: 139-140) reported that *Graptemys* feeds exclusively upon the flesh of a species of viviparous snail. The stomachs of more than twenty specimens contained the bodies and opercula of these mollusks and when the turtles were kept in aquaria the opercula were very numerous in the excreta. Surface (1908) found a specimen to contain only crayfishes. Bishop (1921: 81) confined a specimen in a box and it disgorged several large and many small fragments of the fresh-water clam, *Unio complanatus*. Roddy (1928: 27) wrote that the food of this species is chiefly mollusks and crayfishes but added that water lilies and perhaps other succulent water plants may enter into its diet. Conant (1938: 144) records the following items in the food: crayfish, fish, aquatic insects, carrion, and snails.

Specimens in my laboratory and in the reptile pit at the University Museums in Ann Arbor take chopped beef-heart, fish, and lettuce, as did those reported by Conant (*loc. cit.*). Regarding time of feeding, I have seen specimens feeding during most daylight hours and at night on weedless bottom of sand and marl in Wolf Lake (Van Buren County) and in East Twin Lake (Newaygo County).

My more detailed studies of the map turtle are based on twenty-seven specimens which contained food either in the stomach or colon or in both. These turtles were collected from four inland lakes, two river-mouth lakes,

and two trout and two non-trout streams during the months of May through August (Fig. 3). Six additional specimens were from unknown dates and localities in Michigan. Owing to the fact that the series is so small, no ecological grouping of the material has been made. A summary of food analyses of all the specimens is given in Table 6 and details of numbers and kinds of items eaten in the annotated list.

ANNOTATED LIST OF ITEMS IN THE FOOD OF TWENTY-SEVEN MAP TURTLES

Game fishes.—Identified were one small yellow perch and centrarchids.

Forage fishes.—Three specimens of the northern blacknose shiner were found.

Carrion.—Identified as carrion were the remains of three trout.

Crayfishes.—Of the crushed remains of 13 crayfishes (*Cambarus*), 7 were *C. immunis*.

Water mites.—Three Hydracarina were present.

Insects.—Insects eaten by map turtles were often in immature stages: *Stenonema* nymphs, 2; nymphs of Ephemeroidea, 2; nymphs of Zygoptera, 8; hydrophilid larva, 1; elmids, 274; scarabids, 278; unidentified beetles, 7; lepto-cerid larvae, 68; limnephilid larvae, 58; larvae of *Helicopsyche*, 28; unidentified caddisfly larvae, 70; larval chironomids, 4; larva of *Chironomus*, 1; asilid, 1.

Snails and clams.—Mollusks were well-crushed and often largely decalcified when found. Because of this it was often impossible to obtain counts of the numbers of individuals eaten. In order to give some idea of the numerical relations, the approximate numbers were then estimated when possible as "few" (less than 5), "several" (5-12), "many" (12-100), or "very many" (more than 100). Identified were: *Lymnaea catascopium*, 24; *Lymnaea palustris*, 5; *Helisoma trivolvis*, 8; *Helisoma antrosomum*, many; *Helisoma campanulatum*, 3; *Gyraulus parvus*, many; *Gyraulus* sp., several; *Planorbula armigera*, 2; *Physa gyrina*, 4; *Physa sayii*, many; *Valvata tricarinata*, 4; *Valvata bicarinata perdepressa*, 2; *Valvata* sp., many; *Amnicola integra*, 5; *Amnicola limosa*, many; *Amnicola lustrica*, many; *Amnicola walkeri*, 5; *Amnicola* sp., many; *Bithynia tentaculata*, many; *Campeloma*, several; *Lioplax subcarinata*, 1; *Goniobasis livescens*, few; *Goniobasis* sp., many; *Sphaerium*, 1; *Psidium abditum*, very many; *Psidium* sp., several; *Lampsilis siliquioidea*, several; *Strophitus rugosus*, few; *Anodonta grandis*, several.

Plants.—Plant remains were classifiable as filamentous algae, several *Potamogeton* seeds, *Ceratophyllum*, and vegetable debris.

SUMMARY AND CONCLUSIONS

The game fishes found in map turtles were represented only by the head of a small yellow perch in one stomach and traces of the remains of two centrarchids in one colon, and forage fishes by three northern blacknose shiners in one stomach. The fishes in the stomachs were apparently alive when taken.

The data in Table 6 indicate that crayfishes, mollusks, and insects are

principal foods of this turtle. The broad alveolar surfaces of the jaws of these animals are useful in crushing mollusks and other hard-bodied invertebrates. Evidence of this is the crushed condition of the crayfishes, beetles, snails, and clams in the stomachs examined.

It is not evident whether the small amounts of plant tissue in four colons had been taken primarily or secondarily. The occurrence of several seeds of *Potamogeton* in one colon suggests that perhaps hard-coated seeds of this type are definitely taken as food. The coats of these seeds had been broken open by the action of the jaws, by digestion, or by abrasion from accompanying snail shells.

Numerically the food items are dominated by insects and mollusks. The marl beetles (Elmidae), which appeared in greater numbers than any of the other groups of insects, occurred mostly in one colon, which contained 271. These beetles are very small and are thus far from being as volumetrically significant in the food as the numbers would seem to indicate.

Identifications of mollusks eaten were made as specifically as possible in order to establish not only the predator-prey relationship for the several forms, but also to provide a tool for the use of parsitologists in studying important fish parasites or human pests such as swimmer's itch (*schistosoma dermatitis*). It is evident that in destroying many of the molluscan hosts of such parasites, the map turtle may be a distinct economic asset. This may outweigh some of the competition which it obviously offers to fishes for food.

TABLE 6.—The Food of the Map Turtle in Natural Waters in Michigan.

Based on twelve stomachs containing 38.2 cc. of food and twenty-four colons containing 95.6 cc. of food, from twenty-seven turtles, collected on six lakes, four rivers, and some unknown waters.

Food Item	Stomachs		Colons	
	Composition	Frequency	Composition	Frequency
	by Volume (%)	of Occurrence (%)	by Volume (%)	of Occurrence (%)
Game fishes	1.8	8.3	TRACE	4.2
Forage fishes	11.3	8.3	-----	-----
Fish remains	2.4	8.3	0.6	8.3
Carion	5.0	8.3	-----	-----
Crayfishes	52.4	8.3	13.0	25.0
Water mites	-----	-----	TRACES	8.3
Insects	8.6	41.7	12.0	50.0
Snails	17.3	83.3	57.7	79.2
Clams	1.3	8.3	12.5	37.5
Plants	-----	-----	4.2	16.7

CHRYSEMYS PICTA: BELLII (Gray) $\times$ MARGINATA (Agassiz) Intergrades
between Bell's Turtle and Mid-western Painted Turtle

Range and Size.—As shown by Hartweg (MS) *Chrysemys picta* is represented in lakes, ponds, and streams on most of the Upper Peninsula in Michigan by intergrades between *bellii* and *marginata*, whereas the mid-western

painted turtle (*Chrysemys picta marginata*) is restricted to the Lower Peninsula. The eight adult intergrades which I studied for food averaged 146.6 mm. (5.7 inches) in length, ranging from 126 to 129 mm.

Food and Feeding Habits.—Four of the eight intergrades were collected for food study from a small pond about nine miles northeast of Engadine, Mackinac County, on July 17, 1937. The other four were taken from Pickerel Lake, near Marquette in Marquette County on July 27-29, 1937. It is unfortunate that so few specimens were obtained, but the conclusions drawn from extensive material of *C. p. marginata* presumably may apply also to the intergrades. The results of the analyses of the food of the small series of intergrades are given in Table 7.

ANNOTATED LIST OF ITEMS IN THE FOOD OF EIGHT INTERGRADES BETWEEN BELL'S TURTLE AND MID-WESTERN PAINTED TURTLE

Frogs.—Remains of two frogs (*Rana*) were found in one stomach.

Crustaceans.—Crayfishes present were: *Cambarus propinquus*, 1; *C. diogenes*, 1; *Cambarus* sp., 5. Several Cladocera were also found.

Insects.—Insects were an ephemerid nymph; *Anax junius* nymphs, 2; *Libellula* adult and nymph, 2; *Sympetrum* nymph, 1; unidentifiable dragonfly nymphs, 3; adult of *Lestes*, 1; adult of *Ischnura*, 1; damselfly adult, 1; corixid adults and nymphs, 15; belostomatid adults, 2; *Pelocoris* adult, 1; dytiscid adults and larva, 9; hydrophilid adults, 2; unidentified adult beetle, 1; lepto-cerid larvae, 12; unidentifiable caddisfly larva, 1; sphingid larva, 1; lepidopterous adults, 2; chironomid larvae, 287.

Snails and clams.—Snails present were one *Helisoma trivolvis*, a few *Amnicola limosa*, and a few other individuals. Clams (*Musculium truncatum*) occurred sparingly.

Cryptogams.—Algae identified were *Scenedesmus quadricauda*, *Mougeotia*, *Spirogyra*, and *Hyalotheca dissiliens*. A little moss was also found.

Phanerogams.—Flowering plants were represented by *Potamogeton*, *Sagittaria*, *Nymphaea odorata*, and some unidentifiable fragments.

SUMMARY AND CONCLUSIONS

Insects and their aquatic larvae, and crustaceans, mollusks, and aquatic plants appear to be the principal foods of these turtles. The high value for frogs in percentage by volume is due to the occurrence of the remains of two specimens in one stomach.

It is interesting to note the large numbers of hard-coated seeds of the white water lily (*Nymphaea odorata*) ingested. These mature seeds, 813 in number, make up most of the volume of the plant materials eaten. They appear no different in the colons than in the stomachs, and probably remain viable in

passing through the turtle. This observation and others suggest that these animals may be of ecological significance in the dispersal of water lilies.

On the basis of this material, it appears that the intergrades (between Bell's turtle and the mid-western painted turtle) have food habits much like those of the mid-western painted turtle (p. 302) and that these turtles compete with fish for food, but do not prey upon them.

TABLE 7.—The Food of Intergrades Between Bell's Turtle and Mid-Western Painted Turtle in Michigan Waters.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Frog	42.7	14.3		
Crustaceans	6.0	57.1	6.4	57.1
Insects	15.4	85.7	7.7	57.1
Molluscs	8.5	42.9	0.8	28.6
Cryptogams	TRACE	14.3	3.4	28.6
Phanerogams	24.8	57.1	79.9	85.7
Vegetable debris	2.6	57.1	1.9	57.1

CHRYSEMYS PICTA MARGINATA (Agassiz)—Mid-western Painted Turtle

Range and Size.—The range of *C. p. marginata* has been stated by Bishop and Schmidt (1931: 137) as extending "... from eastern New York through western New York and western Pennsylvania, Ohio, Indiana, and the lower peninsula of Michigan and southeastern Illinois. . . ." (Fig. 5). Average size of adults is 127 mm. (5.0 inches).

Habitat and Habits.—The mid-western painted turtle is the most common turtle on the Lower Peninsula of Michigan, throughout which it is abundant. Very little has been written regarding its habits, whereas the life history and habits of *Chrysemys p. picta* have been rather thoroughly described by several investigators in the eastern states. That there is a close similarity of food habits of the various subspecies and intergrades may be seen by comparing the data which I present with those of Surface (1908) for *C. p. picta* and with those of Pearse, Lepkovsky, and Hintze (1925) for a series of intergrades between *bellii* and *marginata*.

It seems that what Conant (1938: 148) wrote for the mid-western painted turtle in Ohio also obtains for this turtle in Michigan as well as in other parts of its range as described by other authors: they are to be found in almost any locality in which there is sufficient permanent water to hide them and to supply them with food. In Michigan I have collected the turtle from all environments listed by Conant for Ohio (wet meadows, bogs, marshes, woodland pools, brooks, ditches, ponds, lakes) and in addition from a variety of stream habitats. One of the largest catches of this species which I made in an overnight set of one trap was forty individuals. This set was in a bayou of the Muskegon River about seven miles east of Muskegon. The species is very common in the quieter

waters of most larger rivers in the state. Specimens have been seen sunning themselves on objects just out of the water on the Huron, St. Joseph, Kalamazoo, Grand, Clinton, and Saginaw Rivers; all of these are non-trout streams in the southern part of the state. Individuals have been met with in quiet portions of the Black River, a trout stream in Montmorency County. They are often taken at trout rearing stations on such trout streams as the White River (Newaygo County), Platte River (Benzie County), and Silver Creek (Iosco County). Artificial impoundments, used for pond-fish propagation, such as those of the Wolf Lake and the Drayton Plains State Fish Hatcheries, are also frequented by these turtles. In all such waters they are

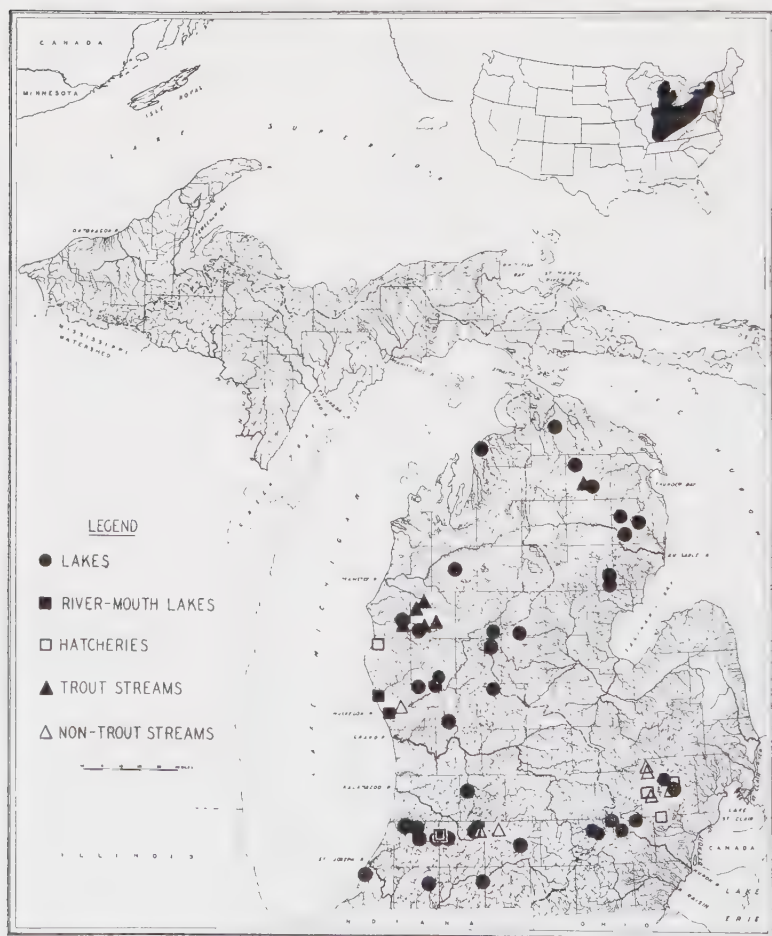


Fig. 5. Types and locations of waters from which western painted turtles were studied and range of this turtle in the United States.

most common per unit area where a soft bottom supports a luxuriant, though not over-abundant, aquatic vegetation.

Mid-western painted turtles in Michigan have been collected by me from environments where they are associated with musk, snapping, Blanding's, map, and soft-shelled turtles. In lakes the most common associates of the painted turtles appear to be the snapping and Blanding's turtles, and the musk turtle within the limits of its range. In the larger rivers of the southern part of the Lower Peninsula, its habitat seems to be shared for the most part with the map turtle.

Food and Feeding Habits.—In so far as I have observed, the mid-western painted turtle is entirely aquatic in its feeding activities although several investigators claim that the species exhibits certain terrestrial tendencies. Specimens in the wild are active feeders and during summer months they have been observed foraging on the bottom in shallow water at night and in the early morning and evening hours. At mid-day they were usually basking.

Food studies of this subspecies based on smaller numbers of specimens by Newman (1906), Hankinson (1908), Baker (1916), Conant (1938), and Raney (1942) substantiate the current findings.

My food studies of the mid-western painted turtle are based on the stomach contents of 413 specimens from fifty-five lakes or ponds, seven non-trout and four trout streams, and five fish cultural establishments. Collections were made during the months of May through October, mostly in 1937 and in 1938 from localities well-spread over the Lower Peninsula (Fig. 5). The material is doubtless adequate to indicate the food of this turtle, but information on certain special phases of its relation to game fish populations, such as that of predation of eggs and fry, is however, still lacking. Since the number of specimens collected was so large, only the contents of the stomachs were analyzed.

In the following record and discussion of the food habits, the specimens from Wintergreen and East Twin Lakes are considered separately, to facilitate comparison of the food of this species with that of other turtles collected from the same lakes. Individuals from several lakes and ponds have been combined into two groups: (1) those from miscellaneous lakes and (2) those from river-mouth lakes. Additional groups are those from: (1) non-trout streams, (2) trout streams, and (3) fish cultural stations. A summary of the food of this turtle on natural waters is given in Table 8. In the annotated list are presented details of the numbers and kinds of food eaten.

Wintergreen Lake.—A description of this lake has already been given (p. 270). Twenty-one mid-western painted turtles from this lake contained food. Ten measured specimens from this series ranged in carapace length from 94 to 142 mm., averaging 127 mm. (5.0 inches).

Game fishes and forage fishes occurred only once each in this series of specimens. Insects and aquatic vegetation appeared as the principal food. Of the insects, 1387 caddisfly larvae, 919 halipid beetle larvae of the genus *Pelto-*

dytes, and more than 190 mayfly nymphs were the most numerous. Filamentous algae comprised by far the dominant plant material ingested (71.0% of the total volume of food). In three stomachs there were forty-seven wheat grains from food scattered along the shores for waterfowl. Some of the grains were in a very much softened condition in the stomachs, indicating that they were perhaps undergoing digestion.

East Twin Lake.—A brief description of East Twin Lake has already been given (p. 272). The average size for eleven mid-western painted turtles that were measured is 132 mm. (5.2 inches) ranging from 105 to 156 mm. Sixty-two additional individuals trapped in this lake during the summer of 1938 were measured, marked for future recognition, and returned to the water as a part of the population-density and growth-rate investigations being conducted on turtles in this body of water.

A summary of the analyses of the food in the stomachs of the series examined from this lake shows an unusually large percentage composition by volume (16.1%) for game fishes. Since this volume is entirely composed by one young pumpkinseed it is probably not a true index of the food relations. Insects (28.0% of the total volume of food) were almost entirely dragonfly and damselfly and caddisfly larvae. Aquatic vegetation, especially filamentous algae, is the chief component (54.8%) of the food of almost all of the individuals.

River-mouth lakes.—The two river-mouth lakes from which mid-western painted turtles were taken are Muskegon and White Lakes. The general nature of these waters is described on page 273. The thirty-two painted turtles that contained food were collected on the same dates as were the snappers (p. 273); fourteen were obtained from Muskegon Lake and eighteen from White Lake. The average length of these individuals is 124 mm. (4.9 inches) ranging from 32 to 154 mm.

As for the two inland lakes just cited, the food of the mid-western painted turtle in these river-mouth lakes is principally insects and aquatic plants. The insects encountered in greatest volume, numbers, and frequency were larvae of hydroptilid caddisflies and aquatic pyralids. The pyralid larvae averaged forty-three per stomach for each of ten turtles in which they were found. Most of them were in houses made of *Lemna trisulca* which, in itself, is often taken as food by the painted turtle in this and other waters. Filamentous algae and *Anacharis canadensis* made up most of the aquatic vegetation found.

Miscellaneous lakes.—These bodies of water are ecologically diverse, but the 152 turtles studied for food from them have been assembled to demonstrate the average nature of the food consumed by a wide-spread and random sample of the total population in lake habitats in the state.

The average length of 136 specimens in this series is 122 mm. (4.8 inches) ranging from 49 to 185 mm.

A summary of the analyses of the food in the stomachs of 152 individuals shows a predominance of insects (15.1% by volume) and aquatic vegetation

(59.0% by volume), which strikingly resembles that of the specimens from the lakes reported individually. Crustaceans (8.3% by volume), including amphipods, isopods, and crayfishes, and mollusks (11.7% by volume) assume a slightly greater role than heretofore. The total absence of vertebrates in this large series is noteworthy.

Non-trout streams.—The mid-western painted turtles for food study from non-trout streams were mostly obtained from the larger rivers in the southern part of the state. Of the fifty specimens in this series, thirty-three were from Price's Bayou on the Muskegon River about seven miles upstream from Muskegon. Others were from the Kalamazoo, Huron, Clinton, and Shiawassee Rivers. As has been indicated, painted turtles are generally very common in the quiet-water portions of such streams and little difficulty was encountered obtaining the sample for study. The average size of forty-five of the specimens studied is 123 mm. (4.8 inches), ranging from 63 to 159 mm.

A compilation of the food found in this fifty specimens discloses an increase in the amount of crustaceans (11.5% of the total volume of food) over those of the previous lacustrine series. This increase may be due to the greater numbers of these organisms, particularly of crayfishes, that exist per unit area in lotic than in lentic environments. Insects, mostly aquatic nymphs and larvae, retain a position of some importance (9.9% by volume). Both by volume (72.8%) and by frequency of occurrence (in more than half of all the stomachs examined) aquatic vegetation is again exhibited as the chief food.

Trout streams.—Only five mid-western painted turtles were available for food habits study from trout streams. Aquatic insects (particularly caddisflies and blackflies) and their nymphs and larvae are the most important food of the turtle in this type of habitat. Crayfishes and small frogs are also represented.

Fish hatcheries.—Nineteen specimens collected at fish hatcheries contained food. Fifteen measured individuals ranged from 105 to 153 mm., averaging 127 mm. (5.0 inches).

Ten of the turtles in this series were taken from one of the fish rearing ponds at the Sunset Water Gardens (Oakland County) while it was being drained. This pond was being used for the propagation of bait and forage minnows and goldfish. At the time of draining, the turtles were concentrated with very many young fishes near the outlet, in a small pool of water with a surface area less than one-tenth that of the bottom of the pond. The remaining nine specimens were from the bluegill and bass rearing waters at the Wolf Lake Hatchery (Van Buren County), bluegill or forage fish rearing ponds at the Drayton Plains Hatchery (Oakland County), and a trout raceway at the Pentwater Rearing Station (Oceana County). In spite of the fact that all these rearing enclosures are shallow over their entire area and that they contain abnormally high concentrations of small fishes, only a single, small bluntnose minnow represented the propagated species.

Carriion appeared as a food item of some importance by volume but was

entirely composed of the remains of a large bluegill in the stomach of one turtle which was shot while feeding on a dead fish.

Insects taken included some forms, such as mayfly and dragonfly nymphs and caddisfly larvae, which are important as food for the fish being cultured in these waters. To counterbalance this possible liability as a competitor for food, the consumption of predaceous beetles and 1570 mosquito pupae must be recognized as an asset.

ANNOTATED LIST OF ITEMS IN THE FOOD OF 413 MID-WESTERN PAINTED TURTLES

Game and pan fishes.—Only a very few species of fishes valued for sport were found. They were one of each of the following: yellow perch; largemouth bass; pumpkinseed; black crappie.

Forage fishes.—A bluntnose minnow, an unidentified minnow (Cyprinidae), and remains of four percids, presumably darters, composed the few forage fishes eaten.

Other vertebrates.—Vertebrates other than fishes were represented only by the remains of a frog or toad.

Carrion.—Identified as carrion were fish remains, some identifiable as bluegills.

Miscellaneous invertebrates.—Several different kinds of invertebrates, other than insects, were eaten by painted turtles as follows: earthworms, 9; leeches, 13; scuds (mostly *Hyaella knickerbockeri*), 90; sow bugs (Porcellionidae), 177; crayfishes (*Cambarus*), 37, of which 2 were *C. virilis* and 1 *C. propinquus*; 2 spiders; and 18 water mites including *Koenikea concava*, *Piona pugilis*, and *Piona reighardi*.

Insects.—Insects in considerable numbers and in a large variety of kinds were identified as follows: grasshoppers (Tettigoniidae) numbered 5 and included representatives of the genera *Scudderia*, *Nemobius*, and others; an antlion; mayfly nymphs numbered more than 110 and were principally composed of *Hexagenia*, *Isonychia*, *Ephemerella bicolor*, *Caenis*, and many unidentifiable Baetidae; besides 88 unidentifiable dragonfly nymphs, others (mostly nymphs) were 14 *Gomphus exilis*, 2 *Anax junius*, 5 *Macromia*, 1 *Tetragoneuria*, 2 *Tetragonia*, 1 *Epicordulia princeps*, 14 *Libellula luctuosa*, 1 *Libellula* sp., 5 *Sympetrum rubicundulum*, 8 *Sympetrum* sp., 18 *Leucorrhinia*, 1 *Celithemis elisa*, 61 *Celithemis eponina*; damselfly nymphs and adults were, 45 unidentifiable, 33 *Lestes*, 1 *Enallagma*, 1 *Ischnura verticalis*, 1 *Ischnura* sp., 1 *Argia violacea*, 3 *Argia* sp.; more than 75 adult Hemiptera including 1 *Notonecta undulata*, 3 *Notonecta lunata*, 4 *Plea striola*, 1 *Belostoma*, 12 belostomatids, 1 *Lethocerus*, 24 naucorids, 2 *Pelocoris*, and 24 gerrids; Homoptera were represented by an aphid; Coleoptera, rather numerous both as adults and larvae of aquatic and terrestrial forms, were 2 adults of *Haliphus*, 1032 larvae of *Peltodytes*, 17 haliplid larvae and adults, 18 larvae and adults of the family

Dytiscidae, 1 gyrtinid, 1 larva of *Berosus*, 2 hydrophilids, 2 carabids, 1 elaterid, 2 buprestids, 1 elmidae larva, 1 lagriid, 1 *Macroductylus*, 2 scarabeids, 3 cerambycids, 2 *Donacia*, 3 chrysomelids, 3 curculionids, and remains of 18 unidentifiable larvae and adults; Trichoptera were present as unidentifiable remains of many larval forms as well as many other larvae classified as follows: 1815 hydroptilids, 24 *Hydropsyche*, 15 *Philoptamus*, 1 *Polycentropid*, 14 *Neuronia*, 2 phryganeids, 17 *Leptocella albida*, 185 Leptocerids, 18 *Stenophylax*, 20 limnephilids, and 1 sericostomatid; miscellaneous lepidopterous larvae and adults numbered 18 but 471 additional ones were pyralids; in addition to a few unrecognizable dipterous larvae, sorted out were 29 *Tipula* larvae and pupae, 25 *Triogma* larvae, 1 tipulid larva, 143 *Chironomus* larvae, 119 other chironomid larvae and pupae, and several ceratopogonid larvae and pupae, 1571 culicid larvae, pupae and adult, 36 *Simulium* larvae and pupae, 3 simuliid larvae, 25 tabanids, 2 *Stratiomyia* larvae, 1 stratiomyid larva, 1 asilid, 1 empidiid pupa, 1 anthomyid, 2 calliphorid larvae, and 1 *Sepedon*; of 3 Hymenoptera present, one was referable to the family Tenthredinidae.

Snails and clams.—Except for *Amnicola limosa* of which 107 individuals were found, mollusks were sparingly represented by one or a few of each of the following kinds: *Helisoma trivolvis*, *Helisoma antrosomum*, *Physa sayii*, *Valvata tricarinata*, *Bithynia tentaculata*, *Lasmigona compressa*, *Sphaerium sulcatum*, and *Pisidium*. Remains of a few other snails and clams were not referable to any of the above.

Cryptogams.—Lower plants, principally filamentous algae, were represented by quantities of each of the following genera and species: *Volvox*, *Oscillatoria princeps*, *Oscillatoria*, *Lyngbya*, *Ulothrix*, *Cladophora glomerata*, *Cladophora*, *Rhizoclonium hieroglyphicum*, *Pithophora varia*, *Oedogonium*, *Pediastrum boryanum*, *Oocystis*, *Spirogyra* sp., *Spirogyra crassa*, *Nitella*, *Cosmarium granatum*, *Phacus brevicauda*, and *Phacus longicauda*. Also present was a little moss.

Phanerogams.—Flowering plants were mostly the leaves and petioles of aquatic kinds; some, however, occurred only as seeds and are thus indicated: *Potamogeton*, *Najas*, *Sagittaria*, *Anacharis canadensis*, *Vallisneria*, *Zea mays* seeds, *Triticum* seeds, *Peltandra virginica*, *Spirodela polyrrhiza*, *Lemna trisulca*, *Lemna minor*, *Polygonum*, *Ceratophyllum demersum*, *Nuphar advena*, *Nymphaea odorata*, *Myriophyllum*, and *Bidens*.

SUMMARY AND CONCLUSIONS

A summary of the food contained in 394 stomachs of mid-western painted turtles from natural waters is given in Table 8 and in Fig. 9. For obvious reasons the material for fish hatcheries is not included here.

These data as well as other observations of earlier investigators, demonstrate conclusively that the mid-western painted turtle species is omnivorous. Insects and other aquatic invertebrates, and aquatic plants, compose the bulk of food of almost all of the individuals studied.

The enumerations and the detailed determinations in the annotated list bring out the ecological inter-relations of predator and prey and facilitate evaluation of the data from an economic point of view. Although the great importance of many kinds of insects in the food is evidenced by the numbers in which they are consumed, the even greater importance of aquatic vegetation is somewhat submerged in this tabulation by the mechanics of presentation. It is interesting to note, for the plant materials, the considerable number of species involved. Additional species have doubtless been overlooked by inability to identify some of the seeds and other plant fragments classified as "vegetable debris."

TABLE 8.—The Food of the Mid-Western Painted Turtle
in Natural Waters in Michigan.

Based on 394 stomachs containing 408.5 cc. of food.

Food Item	Composition by Volume (%)	Frequency of Occurrence (%)
Game fishes	1.0	1.0
Forage fishes	0.3	1.5
Fish remains	0.1	0.8
Frog remains	0.4	0.3
Carion	2.5	1.5
Spiders and water mites	TRACES	3.0
Leeches and "earthworms"	0.4	3.4
Crustaceans	5.0	15.5
Insects	19.5	55.1
Molluscs	5.5	15.7
Cryptogams	30.7	58.9
Phanerogams	30.8	48.2
Vegetable debris	3.7	35.5

The number of game and pan fishes consumed by the painted turtles examined by me is insignificant for fish management. Regarding the oft repeated accusation of egg predation by this and other aquatic turtles, this series of specimens offers only negative evidence. Several of the individuals collected near centrarchid nests contained no trace of eggs or fry of these fishes. Members of this species have, however, been seen by Vern Winey of Kalamazoo on bluegill nests, supposedly foraging on the fry in a position which made the turtles appear to be standing on their heads. No specimens were captured to verify these observations but Winey was certain that fry were present in the nests.

On the basis of the data assembled, the mid-western painted turtle appears to have significance as a food competitor of game and other fishes but may hardly be considered a predator of these forms. The conclusions for this species are very much like those for the musk turtle, for Blanding's turtle, and for the intergrades between mid-western painted and Bell's turtles. Without additional quantitative work on kinds and amount of food available and kinds and amounts actually consumed by associated fish species, I cannot estimate the seriousness of the food competition which they offer to fishes.

AMYDA SPINIFERA SPINIFERA (LeSueur)—Soft-shelled Turtle

Range and Size.—In Michigan the soft-shelled turtle is limited to waters in approximately the southern half of the Lower Peninsula (Fig. 3). Large adults may have a carapace length of more than 16 inches but lengths of ten of the specimens studied for food averaged 236 mm. (9.3 inches), ranging from 162 to 407 mm.

Habitats and Habits.—Few authors have published material on the habitat of the soft-shelled turtle, but all agree that the species is most common in slow-flowing rivers, but that it also occurs in lakes and ponds. In Michigan I have collected specimens from a few lakes of diverse types, in company with musk, snapping, Blanding's, painted, and map turtles. Individuals have been seen basking on the sands near the mouth of the St. Joseph River at St. Joseph and the Muskegon River near Muskegon. Specimens have been taken for me from the Grand and Huron Rivers. On the basis of the relative uncommonness of the species in the lakes studied, I am inclined to believe that Conant's (1938: 159) observation for Ohio that the soft-shell is probably more essentially a river turtle than any of the other species in the state may be equally true in Michigan.

Excellent observations and summaries of the natural history of this turtle are those of Newman (1906), Babcock (1919), Evermann and Clark (1920), Cahn (1937), and Conant (1938). These authors mentioned, as I have also observed, that it is characteristic of this turtle to lie partly buried in the loose bottom material in shallow water. It is remarkable for swimming ability and pugnacity, and for its habit of resting or basking at the water's surface, sometimes at considerable distances from shore. True aquatic respiration has been demonstrated for this turtle by Gage and Gage (1886).

Food and Feeding Habits.—Newman (1906: 131-132) reports the species to be voracious and carnivorous, feeding principally on crayfishes and the larvae of large insects. He has watched them, as have I, crawl or swim along the bottom, pushing their snouts under stones and into masses of aquatic vegetation, occasionally snapping up a crayfish or larva that they have succeeded in dislodging. True (1893: 152) reported that soft-shelled turtles include a variety of vegetable matter in their food. Surface (1908) examined two specimens and found both to contain crayfish and one with crushed beetles. Babcock (1919: 424-425) reported fresh-water mollusks (*Anodonta* and *Campeloma*), small fishes, tadpoles, and frogs as the diet of this species.

Food habits in captivity disclose a carnivorous nature as reported by Conant (1938: 160) who observed that captives ate a great variety of food including crayfish, worms, insects, snails, fish, and meat, but none were observed to take vegetable matter. Gloyd (1928) previously had found that captives would take crayfishes and scraps of meat. One young individual of this species which was fed water fleas (*Daphnia*) and canned fish ("Balto") in our laboratory for seven months apparently thrived.

My food studies of the soft-shelled turtle are based on fifteen specimens

which contained food either in the stomach or colon or in both. These turtles were collected from seven lakes and two non-trout rivers in the Lower Peninsula (Fig. 3). Owing to the small number of specimens obtained for study, no separation of the material into ecological units has been attempted. A summary of the analyses of the food contained in the stomachs and colons of these individuals is given in the annotated list and in Table 9.

ANNOTATED LIST OF ITEMS IN THE FOOD OF FIFTEEN SOFT-SHELLED TURTLES

Fish remains.—Fragmentary remains of 1 fish were found.

Crayfishes.—Of 22 crayfishes (*Cambarus*) 2 were *C. virilis*; 2, *C. immunitis*; 9, *C. propinquus*; and 5, *C. robustus*.

Insects.—Excepting adults of two dytiscids and one damselfly, all insects were nymphs as follows: 172 *Hexagenia*, and 41 dragonflies, including 24 of *Gomphus*, 1 of *Anax junius*, and 1 of *Celithemis*.

Snails.—Gastropods were represented by a single unidentified individual.

Cryptogams.—Lower plants were in evidence as small amounts of filamentous algae and a little moss.

SUMMARY AND CONCLUSIONS

The statements of Newman (1906), Surface (1908), and Evermann and Clark (1920) on the importance of crayfishes and insects in the food of the soft-shelled turtle anticipated my findings. The occurrence of algae, moss, and vegetable debris seems to support True's (1893) conclusion that aquatic plants are food for this species. This plant material occurred in such small amounts, however, that I could not be certain that it was taken primarily. That plant matter may at times be an important food for this turtle, however, is evidenced by Surface's (1908) findings of considerable quantities of corn in a specimen which he examined from Ohio.

TABLE 9.—The Food of the Soft-Shelled Turtle in Natural Waters in Michigan.

Based on eleven stomachs containing 45.8 cc. of food and six colons containing 35.3 cc. of food.

Food Item	Stomachs		Colons	
	Composition by Volume (%)	Frequency of Occurrence (%)	Composition by Volume (%)	Frequency of Occurrence (%)
Fish remains	TRACE	1.9	-----	-----
Crayfishes	47.4	45.5	46.7	66.7
Insects	52.4	90.9	53.3	83.3
Snails	0.2	9.1	-----	-----
Cryptogams	TRACE	9.1	TRACE	33.3
Vegetable debris	0.2	27.3	TRACE	33.3

Burrowing mayfly nymphs of the genus *Hexagenia* are the most important insect food of my series of specimens. Dragonfly larvae are next most significant. The remains of the fish found in one stomach may or may not reflect the scavenging habit recognized for this species by Cahn (1937) and others.

The material above reported yields no positive information on the relations of this turtle to fish populations. Cahn's (1937) information on the food of the soft-shell is a mere species list and does not bring out the frequency, volumetric, or numerical relations involved. His list of the fishes eaten, the turtle's known skill in capturing food organisms, and its remarkable natatorial ability as described by Newman (1906), suggest a possible economic significance that has not been evident in the present series. Surface's (1908: 123) assertion that "In devouring Crayfish . . . any creature is objectionable from the fact that it is one of the most important foods of the carnivorous fishes" is perhaps an overstatement. The soft-shelled turtle does very obviously compete, to some extent, with game fishes for food. The data available yield no information on how serious this competition may be.

Economic Relations of Michigan Turtles with Special Reference to Fish Management

Because they are not abundant and because they seldom inhabit game-fish waters and do not customarily feed on fish, the spotted, the wood, and the box turtles can be of no concern in fish management.

The musk turtle, Blanding's turtle, map turtle, painted turtles, and soft-shelled turtle appear to be of far greater significance as competitors with fishes for food than as predator on fishes. That these species may feed upon the eggs and fry of fishes, particularly those of centrarchids, is suggested by the present data, but the extent and effects of such feeding have not been determined.

The snapping turtle preys on game and pan fishes for about one-third of its food but most of the individuals eaten are of a size less than one-half the legal length, and the number taken is probably less than one per feeding. Therefore this turtle appears to be a less important fish predator than heretofore commonly supposed.

By eating large amounts of aquatic vegetation, the snapping and painted turtles are shown to exert some pressure in the cropping of such plants. Where the fish population is limited by a deficient growth of plants, this habit may have a deleterious effect. However, this possible harm to plant beds may be largely offset through the dispersal of higher aquatics accomplished by the passage of apparently undigested seeds through the alimentary canal of turtles.

The aquatic turtles studied are omnivores since they feed on both plants and animals.

The malacophagous habits of the aquatic species, especially the musk turtle and map turtle, may be of significance in reducing the incidence of those parasite-pests of higher animals which inhabit mollusks during stages of their life-cycles.

The food of turtles indicates a possible role in the control of insect pests with an aquatic phase in their life histories. More than one thousand mosquito larvae were found in one mid-western painted turtle.

Snapping and soft-shelled turtles have considerable significance as human food and all other species in the state are edible excepting possibly the musk turtle. It seems justifiable to recommend the conservation of the marketable species by limiting the sizes which may be taken to six inches or more, lengthwise through the carapace, and by setting the mesh of traps at three inches square. The potential food value of all other species and the finding that they are not fish predators suggests that legislation be enacted to prevent the wanton destruction that is often their fate.

The removal and exclusion of turtles from fish rearing waters seems to be called for because of the damage which they may inflict on unusually high concentrations of fish.

Snappers were not found to be serious predators of young waterfowl even in a sanctuary lake and the assertion of many previous workers in regard to waterfowl-snapping turtle relations are regarded as overstatements.

The need for investigation on several additional problems dealing with the economic relations of turtles is apparent. A knowledge of frequency of feeding and rate of digestion would greatly enhance the value of the data already in hand. Detailed study of the extent and effects of predation on eggs and fry of fishes would doubtless be a profitable venture. And there exist numerous other subsidiary problems which have been suggested in the body of the text.

Summary

(Figs. 6-9)

For several reasons it is important in food studies to record for each organism eaten the kind (identified as specifically as possible), the numbers of individuals (determined by actual count whenever practicable), as well as the frequency of occurrence and volumetric relations.

A close similarity (approaching identity) of the data for separate, small series of specimens from ecologically similar habitats provides a criterion for judging the adequacy of the material for any one turtle species.

For each species are given: (1) general range and distribution in Michigan; (2) a summary of the published information on habits and habitat augmented by original observations in Michigan; and (3) detailed analyses of the food and feeding habits. Original data on food and feeding habits and cognate ecological observations are presented for the musk, snapping, Blanding's and mid-western painted turtles. For each of these species, as well as for the wood turtle, intergrades between Bell's and mid-western painted turtles, map turtle, and soft-shelled turtles detailed lists of specifically identified food items demonstrate some of the ecological relations involved.

In the food of the musk turtle fish carrion and aquatic insects, mollusks, and plants are predominant.

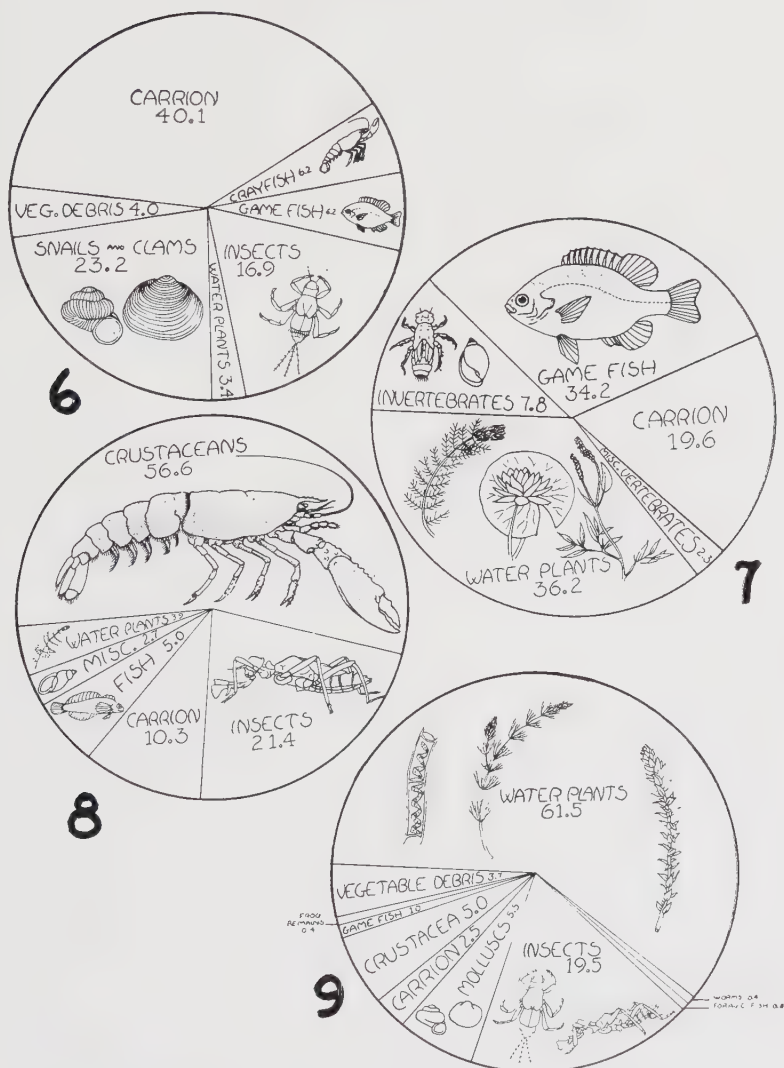


Fig. 6. Percentage composition by volume of the food in the stomachs of seventy-three musk turtles.

Fig. 7. Percentage composition by volume of the food in the stomachs of 173 snapping turtles.

Fig. 8. Percentage composition by volume of the food in the stomachs of fifty-one Blanding's turtles.

Fig. 9. Percentage composition by volume of the food in the stomachs of 394 mid-western painted turtles.

In contrast to the findings of most previous workers, great significance of aquatic plants in the food of the snapping turtle is established.

The most important food materials found in the stomachs of snapping turtles were water plants, fish, carrion, crayfish, mollusks, and aquatic insects. Invertebrates, principally crayfishes, and aquatic plants dominated the colon contents.

The spotted turtle feeds principally on crustaceans and aquatic insects and their nymphs and larvae.

Wood turtles collected in or near water contained aquatic insect larvae and remains of terrestrial plants.

Crustaceans, mostly crayfishes, and aquatic insect larvae are the outstanding foods of Blanding's turtle.

The box turtle is indicated to feed principally upon succulent land plants and soft-bodied, terrestrial invertebrates.

Crayfishes, mollusks, and aquatic insects are the leading foods of the map turtle.

The mid-western painted turtle feeds mostly upon plants and insects which are to be found in the water. Intergrades between Bell's turtle and the mid-western painted turtle apparently are identical in their food habits with the mid-western painted turtle.

Soft-shelled turtles apparently eat by far more crayfishes and aquatic insect larvae than all other foods together.

It is indicated that, with the possible exception of the snapping turtle, the aquatic turtles of Michigan are probably of greater significance as competitors with fish for food than as predators upon fish. Pending further investigation and with the knowledge that aquatic turtles are beneficial to man because of their scavenger-habits, their suggested role in the control of insect- and parasite-pests, and their potential food value to humans (probably excepting the musk turtle) the conservation of these species is recommended and means for accomplishing this are given. The conservation of the wood and box turtles as currently practiced in New York and New Jersey is also recommended.

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